



Agriculture,
Food Security
and Climate Change



FACCE – JPI Strategic Research Agenda

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NOTE:

The FACCE – JPI Secretariat thanks the many people who have contributed to this document and in particular, those who responded to the stakeholder consultation as well as the members of the FACCE – JPI Governing Board (GB), Scientific Advisory Board (SAB) and Stakeholder Advisory Board (StAB). We also thank the participants of the mapping meetings that were held so far and ERA-NET representatives who participated in the workshop of October, 2011. Finally, we thank all the CSA partners who have contributed to the progress of FACCE – JPI. The basis of the document is the Scientific Research Agenda, elaborated by the SAB and adopted in February, 2010. We note that it is an evolving agenda, thus detailed analysis of all of the core themes by the SAB and through mapping meetings has not yet been completed. At the end of the full mapping process, an update of this Strategic Research Agenda will be developed.

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Contents

Introduction 1

Chapter 1: The Basics of Data Science 2

Chapter 2: Data Collection and Cleaning 3

Chapter 3: Exploratory Data Analysis 4

Chapter 4: Statistical Inference 5

Chapter 5: Machine Learning 6

Chapter 6: Data Visualization 7

Chapter 7: Big Data and Cloud Computing 8

Chapter 8: Ethics and Privacy 9

Chapter 9: Future Trends 10

Foreword	5
Introduction	7
The need for research	7
The food security and environment dilemma	7
The role of Europe	8
What is Joint Programming?	8
FACCE – JPI	8
Methodology - inputs to the Strategic Research Agenda	11
Scientific Research Agenda	12
Mapping Meetings	12
Stakeholders	12
European and international collaboration	12
FACCE – JPI Research goals	15
Key challenges	17
An integrated research agenda in support of strategic goals	17
Core theme 1: Sustainable food security under climate change	18
Core theme 2: Environmentally sustainable growth and intensification of agriculture	20
Core theme 3: Assessing and reducing trade-offs between food supply, biodiversity and ecosystem services	22
Core theme 4: Adaptation to climate change	26
Core theme 5: Mitigation of climate change	30
Summary: Main research issues in the five core research themes	34
Delivery of the Strategic Research Agenda	37
Instruments	37
Horizontal programmes and activities	38
• Infrastructures and platforms	38
• Education, training and capacity building in Europe	39
• Knowledge exchange	39
• Communication and dissemination	40
Evaluation and monitoring	41
Conclusion	41
Annexes	43
Annex 1: Scope of the FACCE – JPI	43
Annex 2: FACCE – JPI Governance and membership	44
Annex 2.1: Permanent governance	44
Annex 2.2: GB membership	44
Annex 2.3: SAB membership	45
Annex 2.4: StAB membership	45
Annex 3: FACCE – JPI meetings since 2010	46
Annex 4: Thematic complementarities between FACCE – JPI and ERA-NETs	47

Foreword



One of our greatest societal challenges is food security ¹. Although our planet is able to feed all its inhabitants, nearly one billion people suffer from malnutrition, while another 500 million are obese. Meanwhile, climate change is already affecting agriculture and natural resources are dwindling. Faced with this situation, and that the Earth's population will reach 9 billion people by 2050, it is necessary both to ensure global food security while respecting the imperatives of sustainable development. **Europe has to meet this dual challenge to agriculture** and has already taken a number of initiatives in recent years to promote sustainable development and reduce its emissions of greenhouse gases.

It is in this context that in October 2010, the European Council launched **the Joint Programming Initiative on Agriculture, Food Security and Climate Change** (FACCE – JPI). This initiative brings together 21 Member States and Associated Countries. It is guided by two main priorities:

- **Foster collaboration among national research actors to work toward alignment of research programming.** Let's be clear: the challenges of food security, climate change, and depletion of resources are so important that they cannot be addressed at the national level alone. Even if the work in different countries gives rise to numerous advances, it is imperative to establish a genuine European coordination around a common vision and shared objectives and instruments.
- **Develop innovation at the service of society.** Marked by strong transdisciplinarity, the work carried out in this initiative involves stakeholders so as to be able to also address the economic and social issues, without being limited to the purely scientific ones. Thus it will foster a truly dynamic innovation that will benefit society as a whole, beyond the academic and the agricultural world.

The FACCE – JPI has put in place its road map. Governance is in place: it is based on a Governing Board (GB) and a Scientific Advisory Board (SAB) who have agreed the strategic goals of the JPI and the means to implement them. Civil society (NGOs and consumers), farmer organisations, industries, administration, and European and International programmes/initiatives are represented by a Stakeholder Advisory Board (StAB) allowing them to participate in the development of the JPI. For the general public, the facejpi.com web site provides useful information on the progress of this initiative.

With the adoption in October of the Strategic Research Agenda, FACCE – JPI has made an additional important step forward. Starting with a Scientific Research Agenda, a large number of activities, including for example mapping of research programmes and a public stakeholder consultation, have identified potential joint actions, including some that the FACCE – JPI Governing Board has already started implementing.

This strategic research agenda structures the current and future actions around **five major interdisciplinary scientific themes**:

- Sustainable food security in the context of climate change,
- Environmentally sustainable growth and intensification of agricultural systems under current and future climate and resource availability,
- Assessing and reducing trade-offs between food production, biodiversity and other ecosystem services,
- Adaptation to climate change throughout the food production chain,
- Greenhouse gas mitigation, carbon sequestration and fossil-fuel substitution in the agriculture, forestry and land use sector.

In two years, the FACCE – JPI has already resulted in several concrete achievements. Innovative solutions are at the heart of this dynamic: whether on water use, crop management or the protection of biodiversity, FACCE – JPI identifies innovative solutions applicable at a global level down to the local level. The FACCE Knowledge Hub MACSUR is one example of an innovative means of aligning national research around the theme of modeling climate change impact on European agriculture.

Our joint programming initiative will provide expertise and tools for decision support in the areas of agriculture, food security and climate change to European policies and initiatives such as the Common Agricultural Policy, the European Innovation Partnership on Agricultural Productivity and Sustainability and the Bioeconomy strategy.

We would like to express our sincere thanks to all who have contributed to this progress, and in particular the Secretariat, and we look forward to the future development of our initiative that will mark a milestone in the construction of a genuine **European Research Area** on agriculture, food security and climate change.

¹ The UN-FAO World Food Summit 1996 created a definition, which is used in the context of the JPI: 'Food Security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life.'

Marion Guillou
Chair of the Governing Board



Jean-François Soussana
Chair of the Scientific Advisory Board



Tania Runge
Chair of the Stakeholder Advisory Board



Introduction



The need for research ²

Today's agriculture and the food systems that it underpins are at crossroads (18). Food security – the availability of and access to sufficient and healthy foods and good nutrition at all times – is central for the well-being of people and nations. Until recently, it was expected that despite climate change and increasing world population, there would be several decades with food surplus – and low prices – ahead (11). Nevertheless, food insecurity has increased in the context of the inter-linked food and economic crisis since 2008. Actions taken so far are not sufficient to overcome the crisis, let alone reduce the chronic food and nutrition security problems (19).

A key challenge is to sustainably increase the global food supply to accommodate a world growing to 9 billion or more people by 2050 while preserving a safe operating space for humanity by avoiding dangerous environmental change (16). Climate change is already negatively impacting food production (4, 12), while the agriculture, land use and forestry sectors contribute almost one third of total greenhouse gas emissions and have a high potential for mitigation (11). As Beddington et al. (1) stated – business as usual is not an option – but what are the alternative options?

A number of recent studies (1, 11, 15) have indicated the need for increasing research efforts in the area of agriculture, food security and climate change. International research programmes (e.g. the CGIAR research programme on Climate Change, Agriculture and Food Security, CCAFS) have been initiated to address this for the developing world. A Global Research Alliance on agricultural greenhouse gases has also been launched (17). The Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE – JPI) has been working over the past two years to define the critical research elements needed for a European response to the challenge of food security under changed conditions of demand, supply and risks. The JPI will highlight the sustainable supply and utilisation of food. FACCE – JPI seeks to achieve, support and promote integration, alignment and joint implementation of national resources under a common

research and innovation strategy to address this large challenge. Cross-border collaboration offers the opportunity for more efficient utilisation of scarce resources and JPIs bring a new dimension to European research through alignment of national activities across participating countries; working together around a common vision and strategic research agenda and pooling limited resources: avoiding duplication, filling gaps and creating critical mass (FACCE – JPI Common Vision, 2012).

The food security and environment dilemma

Nothing is more important to humanity and the stability of societies than a reliable and affordable supply of food. Agriculture and land use change push against several planetary boundaries including greenhouse gases, biodiversity, nitrogen and phosphorus pollution and water availability (10,16). An estimated one third of the world's cropland is losing topsoil faster than new soil is forming and many of the poor live on degraded land (13). Land use change resulting from expansion of agricultural land significantly contributes to CO₂ emission (11). Unprecedented water shortages are also increasingly apparent in many parts of the world, including southern Europe (9) and an increased frequency of temperature and precipitation extremes has caused widespread agricultural production losses in the last decade (4).

In many European countries, the growth trends of the yields of major crops, especially wheat, have declined over the past two decades (14). Moreover, the variability of crop yields has increased as a consequence of extreme climatic events, such as the summer heat of 2003 which led to 36 billion Euros economic losses for the agriculture sector in the EU (11) and to large carbon losses from ecosystems (3), the summer drought and heat in 2010 destroying vast areas of crop stands in Russia, and the 2011 spring drought in France. Future climate change impacts on the European agricultural ecosystems are likely to contrast increases in yield and expansion of climatically suitable areas in northern Europe, and more frequent water shortages and extreme weather events (heat, drought, storms) in southern Europe (2).

² See Soussana, J-F, Fereres, E, Long, SP, Mohren, FGMJ, Pandya-Lorch, R, Peltonen-Sainio, P, Porter, JR, Rosswall, T, von Braun, J (2012) A European science plan to sustainably increase food security under climate change. *Global Change Biology*, 18, 3269-3271.



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Strategic Research Agenda

The role of Europe

The food system in its entirety (including pre-chain inputs, agricultural production, food processing and retailing) is by far the largest industrial sector in Europe (8). An innovative bio-economy in support of a "green growth" strategy that would combine economic growth, natural resource preservation, highly efficient resource utilisation in well integrated value chains and greenhouse gas reduction is also foreseen (7).

Europe has been a global leader in policy and action to decrease greenhouse gas emissions. Not only does the European Union's own production result in significant emissions, but as a net importer of primary agricultural products it causes significant emissions elsewhere (5). However, judicious use of the European land resources supported by agricultural sciences could adapt production to climate change and lower emissions domestically and internationally. Europe is well placed to address these issues since it recognises the significance of global climate change. Europe could therefore provide a space for change, testing an implementation of novel strategic concepts based on new bio-physical and socio-economic research (see also 18).

Moreover, there are significant national R&D investments in Europe in the different areas of the JPI. A report by the Joint Research Centre ³ of the European Commission indicated that in 2009, the total estimated public national R&D investment of all EU Member States on agriculture, food security and climate change as a whole ⁴ is of around €1,535 billion, while the total estimated public national R&D investment of all JPI members (including Associated Countries) amounts to around €1,583 billion.

However, and although they pertain to topics of great societal importance, these resources are to a large extent engaged independently from one another, or at least with no European-scale strategy. Such a strategy is the goal which has been set for JPIs by the European Commission in July 2008: to pool these national resources to create critical mass and consistent funding for research, align national research programmes, reduce overlaps, fill gaps and list EU-wide relevant priorities.

What is Joint Programming?

Joint Programming Initiatives are intergovernmental collaborations meant to tackle grand societal challenges that cannot be solved solely on the national level and thus contribute to the realisation of a European Research Area ⁵. Joint Programming is considered as a process that will operate over the long-term.

In Joint Programming, Member States are motivated to coordinate national research activities, group resources, benefit from complementarities and

develop common research agendas, to overcome bottlenecks and to provide the long-term, stable research base that is needed to address major societal challenges. Participation is on a voluntary basis with variable geometry: partners participate in actions that are in line with their national research priorities.

FACCE – JPI

The Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE – JPI) was among the first JPIs to be launched by the European Council (October 2010). Its foundations were set up in the discussions carried out in SCAR collaborative working groups and brought forward through a Franco-British initiative to establish what FACCE – JPI is today: an initiative bringing together 21 countries ⁶ that are committed to building an integrated European Research Area addressing the challenges of agriculture, food security and climate change. Through their representatives on the FACCE – JPI Governing Board (GB; see Annex 2.2), these countries have agreed on a common vision to address these major societal challenges ⁷. Along the lines defined by the FACCE – JPI Scientific Advisory Board (SAB; see Annex 2.3) in a Scientific Research Agenda ⁸, the JPI will provide coordination between the member states in their programming of research to support sustainable growth in agricultural production to meet increasing world food demand and to contribute to sustainable economic growth and a European bio-based economy while maintaining and restoring ecosystem services under current and future climate change.

To do so, a strong interdisciplinary research base, encompassing economic and social aspects in addition to scientific ones, is required. This implies the need for a creative approach towards aligning national programmes. The interrelated challenges addressed are European and global and require the effort of multiple actors and stakeholders at regional, national and European levels. Input is provided by policy makers, the scientific community as well as stakeholders. The latter will provide the JPI with advice through their representatives in the FACCE – JPI Stakeholder Advisory Board (StAB; see Annex 2.4).

To respond to the interconnected challenges of sustainable agriculture, food security and impacts of climate change, the Scientific Research Agenda includes five evidence-based interdisciplinary core research themes:

- 1• Sustainable food security under climate change, based on an integrated food systems perspective: modeling, benchmarking and policy research perspective.
- 2• Environmentally sustainable growth and intensification of agricultural systems under current and future climate and resource availability.

³ K. Haegeman, Agriculture, food security and climate change – Public national R&D investment, research programmes and transnational collaboration in Europe, JRC-IPTS, version 02-09-2010.

⁴ It is important to recognise that there is fairly large uncertainty in these numbers, and the authors analysed the three areas of the JPI, and not the points of intersection which are treated by FACCE – JPI

⁵ http://ec.europa.eu/research/era/areas/programming/joint_programming_en.htm

⁶ Austria, Belgium, Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Ireland, Israel, Italy, The Netherlands, Norway, Poland, Romania, Spain, Sweden, Switzerland, Turkey and UK; see also Annex 2

⁷ <http://www.facejpi.com/Document-library/Vision-paper>

⁸ <http://www.facejpi.com/Document-library/Scientific-Research-Agenda>; see also Annex 1

- 3• Assessing and reducing trade-offs between food production, biodiversity and ecosystem services.
- 4• Adaptation to climate change throughout the whole food chain, including market repercussions.
- 5• Greenhouse gas mitigation: N₂O and CH₄ mitigation in the agriculture and forestry sector, carbon sequestration, fossil fuel substitution and mitigating GHG emissions induced by indirect land use change.

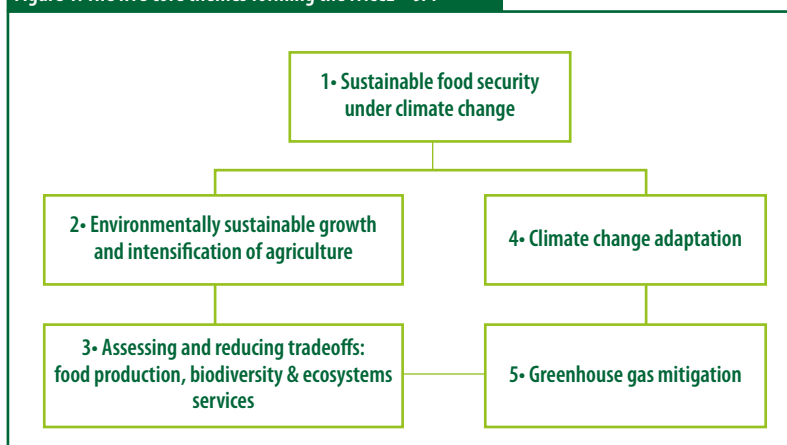
The JPI will need to bring together: core themes (CT) 2 and 3; core themes 4 and 5; core theme one across all. This leads to the following scientific structure (Figure 1) of the FACCE – JPI.

This Strategic Research Agenda has been designed to set out clear policy-relevant research priorities for the short, medium and long-term on agriculture, food security and climate change in Europe, and to list the strategic actions involved to achieve these goals and align current and future national research programmes. The FACCE – JPI research core-themes have been developed by numerous activities described in the Methodology section below.

FACCE – JPI VISION: An integrated European Research Area addressing the challenges of Agriculture, Food Security and Climate Change to achieve sustainable growth in agricultural production to meet increasing world food demand and contributing to sustainable economic growth and a European bio-based economy while maintaining and restoring ecosystem services under current and future climate change.

FACCE – JPI MISSION: to achieve, support and promote integration, alignment and joint implementation of national resources under a common research and innovation strategy to address the diverse challenges in agriculture, food security and climate change.

Figure 1. The five core themes forming the FACCE – JPI



Methodology – inputs to the Strategic Research Agenda



Although building on existing tools and know-how, as a new process many aspects of JPIs need to be “invented” – or at least appropriated by JPI actors. In this sense, JPIs must advance and “learn by doing”, but at each step gain insight on how to improve the process, hence the concept of FACCE – JPI as a cyclical process (Figure 3). In this first iteration of the Strategic Research Agenda, the basis for the future research conducted in the context of FACCE – JPI has been laid down. Joint actions and activities are being planned to implement this agenda and more will arise as the JPI advances. The progress of the JPI toward reaching its strategic goals will be monitored, to allow necessary adjustments to the agenda and the means of implementing it.

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graph TD
    A[Common vision] --> B[Scientific Research Agenda]
    B --> C[Strategic Research Agenda  
To be launched in Dec. 2012]
    C --> D[Implementation of SRA]
    D --> E[Pilot action call]
    D --> F[Preparation ERA-NET Plus]
    D --> G[International call]
    H[Stakeholder public consultation + StAB  
Working with ERA-NETs  
By CT: Mapping meetings  
By CT: SAB + expert discussion] --> B
  
```

Common vision

Scientific Research Agenda

- Stakeholder public consultation + StAB
- Working with ERA-NETs
- By CT: Mapping meetings
- By CT: SAB + expert discussion

**Strategic Research Agenda
To be launched in Dec. 2012**

Implementation of SRA

Pilot action call

Preparation ERA-NET Plus

International call

And others...

The diagram illustrates a continuous cycle of research evaluation and policy development. The stages are connected by arrows in a clockwise direction:

- Scientific Agenda** leads to **SRA**.
- SRA** leads to **Mapping Meetings**.
- Mapping Meetings** (by CT on current and future programmes) leads to **Priorities by Core Theme**.
- Priorities by Core Theme** leads to **Coordinated Projects**.
- Coordinated Projects** (with notes: Alignment of existing research; New calls when needed) leads to **Instruments**.
- Instruments** leads to **Evaluations of actions**.
- Evaluations of actions** leads to **Evaluation of the process**.
- Evaluation of the process** leads back to **Scientific Agenda**.

In the center of the cycle is a box containing the text: **GB decision + SAB and StAB advice**.

On the right side, a triangle connects **SRA**, **Mapping Meetings**, and **National Policies**.

11



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Strategic Research Agenda

Scientific Research Agenda

A board of 12 internationally renowned scientists (Annex 2.3) has been elected to constitute the SAB. Their initial task was to develop a Scientific Research Agenda for FACCE-JPI. The Scientific Research Agenda designed by the SAB has defined five core themes which have been adopted and taken forward in the FACCE – JPI mapping process and which will structure future joint actions. Additionally, short-, medium- and long-term priority actions were described. The full scope of the JPI was described (see Annex 1). The Scientific Advisory Board has further elaborated on three of the core themes and these inputs are included herein.

Mapping Meetings

An innovative system of mapping and foresight meetings on on-going and future research projects and programmes is currently being carried out on each of the core themes defined in the Scientific Research Agenda. During these meetings (see Annex 3 for a list of all JPI meetings to date), posters are prepared by each member country presenting their current and future national programmes as well as their participation in European and international actions. Mapping meetings are complemented by desk studies and bibliometric analyses. The meetings bring together funders and research policy makers as well as scientific experts to analyse the current research and to make recommendations for future research and policy and the means to implement them ¹⁰.

Mapping of core themes is helping to identify:

- 1• Topics on which much research is being done in many JPI countries. These topics are of interest for future alignment, joint actions or instruments.
- 2• Topics on which research is carried out in a small number of JPI countries. These latter are topics for novel alignment activities (e.g. geographic, thematic).
- 3• Topics which are in the Strategic Research Agenda but on which there is little or no research. These topics could give rise to news topics in Horizon 2020 as collaborative projects, joint calls or ERA-NETs.
- 4• Emerging topics. FACCE – JPI will organise workshops, seminars or ideas labs to further explore these topics.

So far, four mapping meetings have been successfully conducted: on mitigation of agricultural greenhouse gases, on climate change adaptation, on trade-offs between food production, biodiversity and ecosystem services and on food security under climate change.

The reports from these meetings are available for downloading from the FACCE JPI website (<http://www.faccejpi.com/Document-library/Mapping-meeting-reports>).

A final “broad based” meeting will conclude the 5 thematic mapping meetings to maximise their outcomes, build synergies with alignment and implementation working groups and to evaluate both the methodology and the process. FACCE – JPI work continues to identify instruments and methods to realise alignment of national activity.

Stakeholders

In order to gather stakeholder views on FACCE – JPI plans and activities, an online questionnaire, structured around the five core research themes of the FACCE – JPI, was used as the basis for a consultation exercise with stakeholders across Europe. The summary of responses is now available ¹¹. For the creation of this Strategic Research Agenda, input from the consultation was used to validate and in some cases expand the subjects to be addressed in the core themes and to highlight supporting activities required by the JPI.

Stakeholder input will continue throughout the FACCE – JPI process through the Stakeholder Advisory Board (StAB; Annex 2.4). A group of 22 European and international stakeholders from 5 broad categories (Civil society, including NGOs and consumers, Farmers, Industry, Administration, including European Technology Platforms – ETPs), themselves representing a great number of other organisations from very various backgrounds, will meet to give advice on the main FACCE – JPI strategic orientations, and will take part in the relevant JPI activities and give relevant technical advice on a case by case basis.

European and international collaboration

FACCE – JPI works with a number of European initiatives and projects (public to public, public-private partnerships), aiming with these collaborations not only to bring further the research and alignment goals of FACCE – JPI, but also to realise the European Research Area. These other European initiatives include ERA-NETs (16 ERA-NETs were identified as relevant for the FACCE – JPI focus. Collaboration with them in the form of joint mapping, best practices and data sharing or joint calls, is well underway as well as participation in a network of bioeconomy relevant ERA-NETs and JPIs: the FP7 project PLATFORM). FACCE – JPI also works with other JPIs (in particular, JPI Climate, JPI Water and JPI Healthy Diet for a Healthy Life) and participates in the FP7 project JPIs-TO-COWORK as well as the European Energy Research Alliance (EERA). Links will further be established with the new European Innovation Partnership on Agricultural Productivity and Sustainability. FACCE – JPI will also work with public-private partnerships such as

¹⁰ The reports from the mapping meetings can be downloaded from <http://www.faccejpi.com/Document-library/Mapping-meeting-reports>

¹¹ <http://www.faccejpi.com/Document-library/FACCE-JPI-Public-Stakeholder-Consultation-Report>

the European Institute of Technology's Knowledge and Innovation Communities (KIC) which focus on bringing together education, technology, research, business and entrepreneurship, in particular, the Climate KIC and the future Food KIC. The FACCE – JPI will also establish links to existing and emerging European research infrastructures, for example ANAEE, MIRRI, ICOS, ELIXIR * etc., seek interactions with the European Strategy Forum on Research Infrastructures (ESFRI) and propose areas where new infrastructures or upgrades of existing ones are necessary (see also the section on “Horizontal programmes and activities”).

On a more global scale, FACCE – JPI recognises the necessity for a global approach to large scale issues as are Agriculture, Food Security and Climate Change. FACCE – JPI is actively developing partnerships with international initiatives going beyond the EU: an International Call on Greenhouse Gases Mitigation with non-European countries from the Global Research Alliance on Agricultural Greenhouse Gases (GRA; <http://www.globalresearchalliance.org/>) and a joint action with the Belmont Forum on Food security and land use change. FACCE – JPI has initiated a collaboration process with other international initiatives, such as the FAO Committee on World Food Security, the European Commission's Joint Research Centre, CGIAR programmes and in particular that on “Climate Change, Agriculture and Food Security” (CCAFS; <http://ccafs.cgiar.org/>) and the Wheat Initiative (<http://www.wheatinitiative.org/>), and will continue to seek strategic links with others.

* ANAEE: Analysis and Experimentation on Ecosystems (<http://www.anaee.com/>)

MIRRI: Microbial Resource Research Infrastructure (<http://www.mirri.org/>)

ICOS: Integrated Carbon Observation System

(<http://icos-infrastructure-france.lscce.ipsl.fr/index.php?p=hom>)

ELIXIR Data For Life (<http://www.elixir-europe.org/>)

FACCE — JPI Research goals



The interactions between agriculture, food security and climate change have been envisioned by the Scientific Advisory Board highlighting the intersections, which are at the heart of the FACCE – JPI (Figure 4). The complex system formed by each of these components and by their interactions is under multiple pressures from external drivers. These include the rising food, feed, fuel and fibre demand, globalisation and global environmental changes and is moreover constrained by planetary boundaries such as land and water limits.

To meet these challenges, research undertaken should be mission-oriented, with four complementary and interactive goals:

i) Provide new approaches for the sustainable growth and intensification

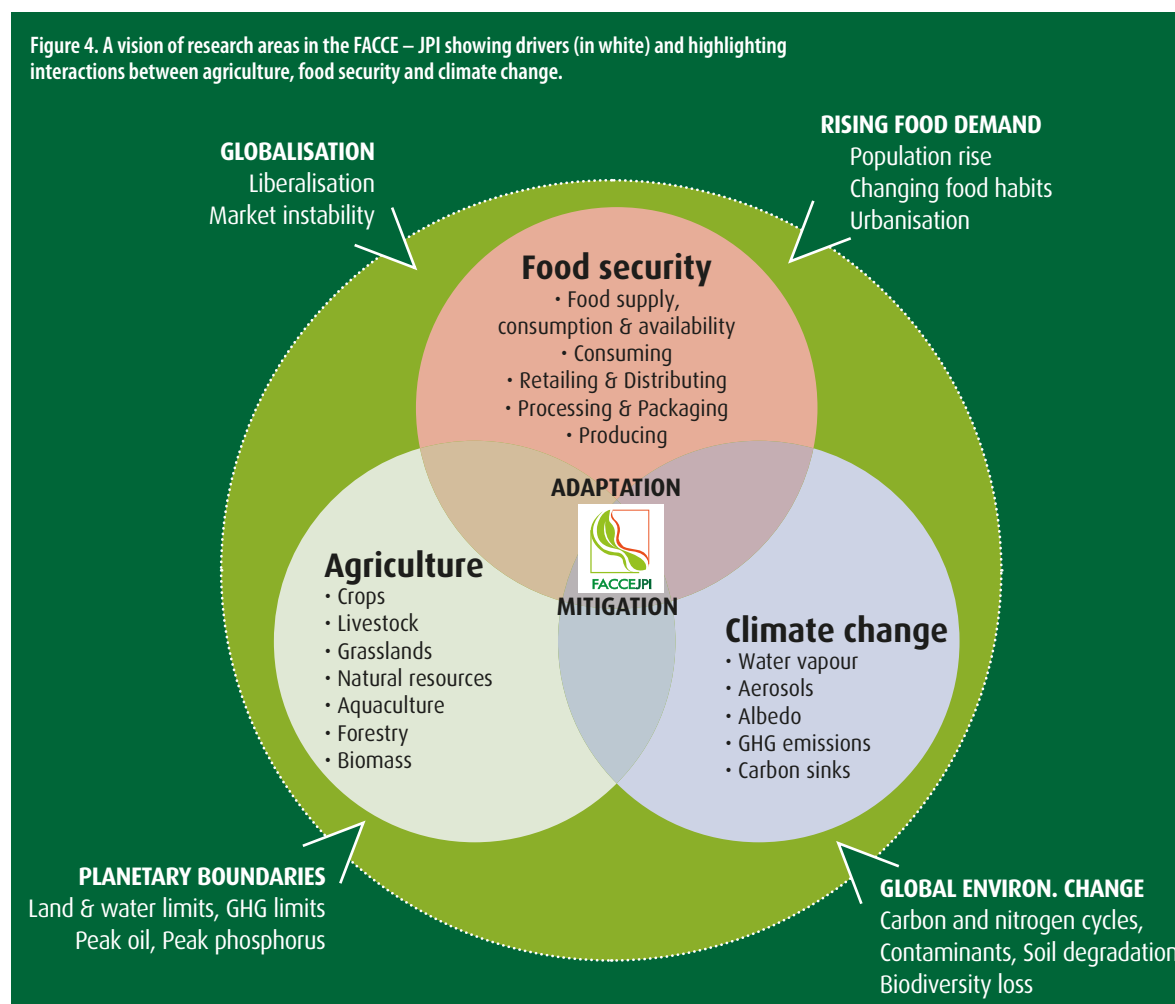
of agriculture in Europe including transformational adaptation and increase the resilience of food systems to deliver European food security, feed, fuel, fibre as well as other ecosystem services under current and future climate and resource availability;

ii) Provide an integrated impact assessment of climate change throughout the whole food chain, including market repercussions;

iii) Contribute to direct reductions of greenhouse gas (GHG) emissions through carbon sequestration, fossil fuel energy substitution and mitigation of N_2O and CH_4 emissions by the agriculture and forestry sector, while reducing GHG emissions per unit area and per unit product associated with land use change;

iv) Sharply reduce trade-offs between food production and the preservation of biodiversity, ecosystem functions and services.

Figure 4. A vision of research areas in the FACCE – JPI showing drivers (in white) and highlighting interactions between agriculture, food security and climate change.



Key challenges



An integrated research agenda in support of strategic goals

To reach these goals, research should be integrated on a large scale:

- A systemic understanding should be gained, by developing and integrating a large range of disciplines from climatology, to ecology, agronomy, forestry and socio-economy, through plant, soil, microbial and animal sciences, that must be strongly connected to a foundation of agro-ecological and socio-economic modeling.
- Key European infrastructures need to be assembled in order to integrate scenarios, observations, experiments and models so as to develop and inter-compare agro-ecological and socio-economic projections while assessing their uncertainties.
- Economics of short- and long-term adaptation/mitigation strategies should be analysed also aiming at improving current food security while taking into account: i) uncertainties in the projections of climate change and impacts, ii) the valuation of ecosystem functions and services and their resilience.
- Developing and implementing specific solutions at the ecosystems and policy levels based on detailed information on regional impacts and meaningful assessment of the adaptive options and their feasibility at local and farm levels. Workable adaptation options will be developed in close collaboration with decision-makers and stakeholders involved in the research and development process.
- A roadmap of breakthrough innovations (technologies and methods) in the areas of crop, livestock, fuel and fibre production, of land, water and genetic resource management and of biodiversity conservation and use will be developed. Social innovation (change of behaviour), organisational (changes in management), and know-how innovation (knowledge around methods and practices) will also be considered. When mature, these innovations will be considered for integration in production systems and in policy measures.

Such an integrated research agenda has been envisioned to deliver impact of European research by contributing: i) to raising the biological efficiency of European agriculture, ii) to responding to a globally increased food demand, iii) to operating agriculture within environmental limits (e.g., greenhouse gas, energy, biodiversity and contaminants) and iv) to building resilience in agricultural and food systems (Figure 5).

The scientific basis of this agenda results from the work of the FACCE – JPI Scientific Advisory Board (SAB) in the form of a Scientific Research Agenda. This scientific research agenda was adopted by the Governing Board of the FACCE – JPI on December 17, 2010. This work allowed the definition of 5 core research themes which structure the FACCE – JPI.

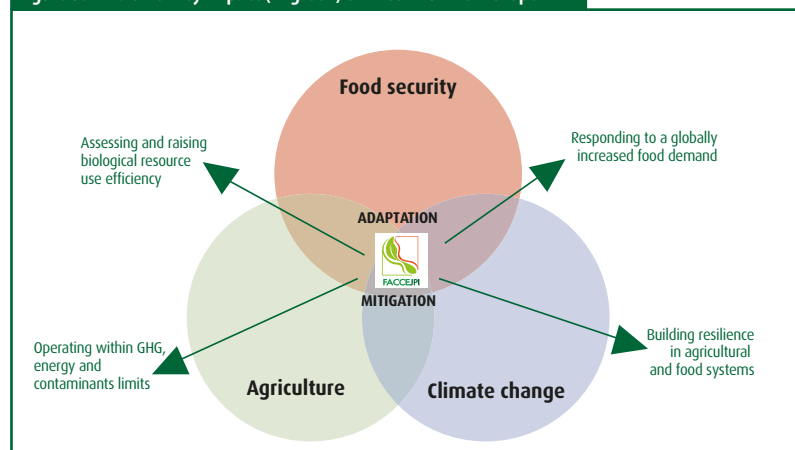
Moreover, the SAB has subsequently analysed three of the core themes in more detail, bringing in scientific experts to expand on gaps and priorities for each theme. These are presented with each core theme.

A set of criteria has been developed in order to select the core research themes of the FACCE – JPI. According to these criteria, core themes should:

- Be evidence based,
- Be ground-breaking at European level,
- Have high expected returns,
- Be of urgency for Europe and/or regions of Europe,
- Reinforce Europe's contribution to global public goods,
- Be interdisciplinary,
- Be integral in developing the research agenda,
- Be complementary, with clear links and synergies within and across themes.

In order to facilitate the start of early actions by the FACCE – JPI, a first list of actions for each core theme (CT) has been identified by the Scientific Advisory Board and complemented with actions highlighted by discussions on current and future programmes that took place in mapping meetings. These lists of actions will be developed further at the conclusion of the mapping and reflected in the update of the Strategic Research Agenda. First illustrative examples of medium and long term actions have also been identified. It is recalled however, that the activities of the JPI are on-going, for example not all core themes have been the subject of mapping meetings, thus this document will be updated regularly as the activities of the JPI advance, and revised at least every two years.

Figure 5. A vision of key impact (in green) of FACCE – JPI for Europe



Core theme 1:

Sustainable food security under climate change

This core theme includes:

- Integrated food systems and the bioeconomy perspective, combining biophysical and socio-economic modeling with policy research perspective;
- Integrated risk analysis of the European agriculture (and food systems) under climate change: test responses to volatility both from natural and market phenomena;
- Global change impact and resilience of food systems (through the value chain and to the consumer);
- Europe's role in international markets, price volatility, global food security impacts;
- Develop contrasted scenarios involving perceptions and policy dialogue;
- Combine observations, experiments and modeling through the development of appropriate European research infrastructures.

Assessment of this core theme through mapping highlighted the following research needs:

- Approaches to understand food systems require **integration of aims and methods** and joint discussions between policy makers, science funders and researchers. In this regard, the following was flagged: i) integration of research on food economics (prices, drivers, markets, etc.) and climate change scenarios; ii) integration of primary production and post-harvest aspects.
- **Scenario building and modeling.** There is a need to increase the effective use of modeling and standardised scenarios to better understand the effects of consumer behaviour on the food chain and decision making, and feedback loops. A more integrated approach examining life cycle analysis and diet is needed, looking at complementarity between foods, food nutrition and environmental consequences of food consumption.
- As **consumers' choices and behaviour** have an important impact in all the steps of the food chain, it is crucial to develop methods to quantify such impact, as changes in the consumer habits may have market repercussions (e.g. changes in food demand and availability), and to improve the access to information to allow consumers to make informed choices and to understand their impact. This can only be accomplished through integrated socio-economic approaches. In this regard, the development of effective regulation (research on this is needed) should play an important role.

• As there are strong links between local, regional and global food markets, the regionalised impacts of climate change on land use and primary production will have unprecedented effects on global supply/demand. In order to establish control measures, further research on **food market price volatility and its relation with climate change** is needed.

• **Impact assessment of policy instruments and regulatory measures.** Research on how development and evaluation of policy instruments takes place, and how to improve ex-ante impact assessment on various scales is highly recommended. Also, an appropriate regulatory framework is critical to face the challenges derived from climate change. There is a need to guard against regulation stifling innovative technological options that would improve food security under climate change.

• **Reduction of food waste** alone will not solve global food security, neither will it make increase of primary production superfluous, but discarding less is a quick win that will alleviate the problem instantly. However, empirical data of the impact is lacking. A good assessment requires looking at food losses in different parts of the food chain (farm level, post-harvest level, transport, processing, markets and consumers). In this regard, the situation in developed countries differs greatly from those of developing countries.

Priority actions:

Short term	• ✓ On-going: Detailed climate change risk assessment for European agriculture in a global context: how will climate variability and change affect regional farming systems in the near and far future? What are the risks and the opportunities for European food security and agriculture? In collaboration with the international projects, an ensemble of crop and livestock models will be benchmarked, inter-compared and coupled to both climatic and economic models. • ✓ On-going: Assessment of land use change in relation to energy and food crop allocation. • Open a call for a 'think tank' in order to help building networks on linking climate change and food security.
Medium term	• Consequences of changes in food systems (including food habits, processing, wastes, consumption...) on climate change (GHG, footprints, etc.) and, conversely, climate change impacts on European food systems. • In order to improve production systems under stress, study the impact of resource limitations on production. • Research to support policy development towards effective regulation that impacts on consumer choices and behaviour.
Long term	• Modeling the drivers of price volatility and its role on food systems and food security. • Use of Representative Concentration Pathways (RCPs) and development of a range of contrasted scenarios including changes in food habits, processing, etc. • Tailored innovation toward local solutions for a better standard of living for rural populations and an increase in regional food security, through involvement of local stakeholders and working with development funds as a source of funding research.

- **On-going joint action: Knowledge Hub MACSUR**
 - "A detailed climate change risk assessment for European agriculture and food security"
 - Launched in July 2011
 - Successful evaluation in January 2012
 - Start in June 2012
 - 15 M € estimated total budget including 8 M € new money
 - 65 research groups from 17 countries participating
 - Interaction with the international project AgMIP
- **Planned joint action with the Belmont Forum**
 - Collaborative Research Action on Food Security and Land use change
 - The FACCE – JPI is preparing and participating in a scoping workshop
 - The Belmont Forum has been invited to the corresponding mapping meeting to discuss complementarities

Core theme 2:

Environmentally sustainable growth and intensification of agriculture

This core theme includes:

- Providing new approaches for improving farm management and for the sustainable intensification of agricultural systems, but also for low-input high nature value systems in Europe under current and future climate and resource availability;
- Understanding recent yield trends in Europe, taking into account changes in costs and prices and research investments as well as changes in environment, management and genotypes;
- Benchmarking efficiencies of resource use (water, land, nitrogen, energy) according to Genotype x Environment (including climate) x Management combinations across Europe;
- Assessing and raising biological resource use efficiency of crop and livestock systems; increasing total factor productivity;
- Combining crop, livestock and bioenergy systems for sustainable intensification;
- Low input, higher efficiency seeds and breeds;
- Knowledge based IT innovations in agriculture;
- Improved understanding and control of soil functioning and biotic interactions at field to landscape scales.

The preliminary conceptual framework* of this core theme highlights the following dimensions to this challenge:

- The development of innovative farming systems that combine economic, social and environmental performance can be fostered by targeted research at the interface between ecology and agricultural sciences. Applying the ecological theory to the design and management of sustainable agroecosystems requires an increased understanding and use of biological diversity.
- Agro-ecological engineering will have to be developed, in particular through the increased use of genetic and species diversity at field and landscape scales. Particular attention will be paid to the ecology and sustainable management of soils and water resources (including restoration technologies) and to the risks of contamination of the environment and along the human food chain.
- Remote sensing and information technologies, such as seasonal weather forecasting, the geo-monitoring of crops and precision agriculture have the potential to reduce inputs while increasing productivity and resilience. Advanced plant and animal breeding (e.g. genomic selection) will be increasingly needed to increase the efficiency of water and nutrients use by crops and of feed by livestock under both optimal and sub-optimal resource availability.

- The design of integrated management strategies for plant and animal health has a strong potential to reduce the use of pesticides and veterinary products while remaining technically and economically successful. Novel monitoring methods of pests and diseases can be deployed to reduce their impacts on crops and livestock systems and deploy resistance genes in a timely manner, while preventing their decay through crop and breed diversification.
- Diversified production systems – including catch crops, crop rotations with legumes, crop-livestock integration and agroforestry – may help in making better use of natural resources, encourage nutrient and carbon recycling and enable high levels of biological diversity. Locally intensive management methods can best be integrated in a more diversified landscape matrix to reduce their environmental impacts.
- Transitions in farming systems towards sustainable intensification, and/or high nature value, needs to be integrated into the broader perspective of a bioeconomy that will combine the recycling of wastes, and the production of food, feed, fibre, chemicals, materials and energy (e.g. biogas, lignocellulose-based biofuels) from biomass. Cradle to cradle value chains can be developed through the integration of industries across rural regions and cities.

* This preliminary framework will be refined by the SAB.

A mapping meeting on this topic is planned for April 2013. Additional priority actions will be developed further in the update of the Strategic Research Agenda.

Priority actions:

Short term	• Benchmarking at farm gate the current state and historical changes (and their main drivers: economics, Genotype x Environment x Management) in productivity and resource use and institutional innovations and investment needs for sustainable intensification. • Assessment of variability in systems by screening a large number of situations, as if taking a meta-analysis approach.
Medium term	• Production of innovative scientific gold standards for agricultural monitoring. Satellite studies where countries could identify key systems with raised productivity and reduced GHG emissions, in which average values of variables can be benchmarked.
Long term	• Combined development of genomic selection, ecological engineering, precision farming, ecotechnologies and biotechnologies for increased resource use efficiency and productivity in key agricultural systems.

√ Planned joint actions: to be confirmed

Core theme **3**:

Assessing and reducing trade-offs between food supply, biodiversity and ecosystem services

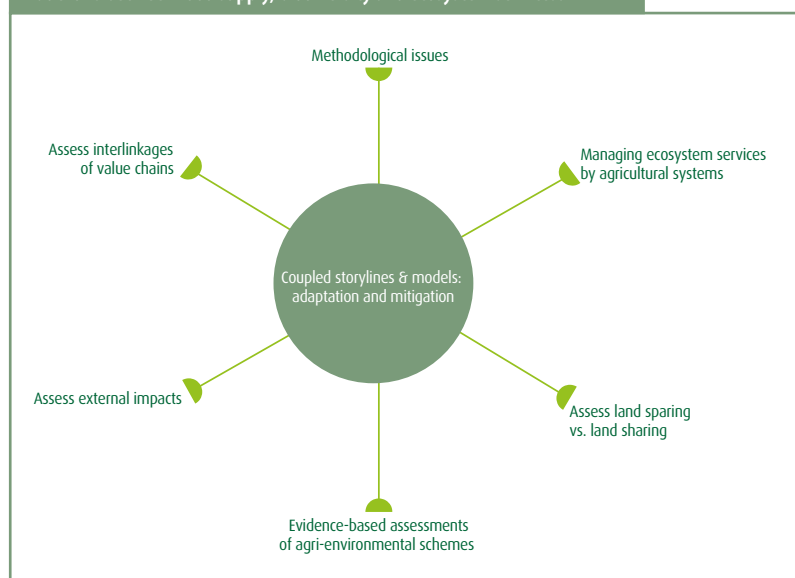
This core theme includes:

- Providing new approaches to the increased use of functional biodiversity in agricultural systems (e.g. intercropping, mixtures, conservation agriculture...);
- Developing methods for assessing and valuing biodiversity and ecosystem goods and services (e.g. carbon sequestration, water storage...) in intensive agricultural systems;
- Developing approaches for optimising the trade-off between agriculture and ecosystem services in a variable environment (climate change, volatility...) and at farm scale and landscape scale;
- Developing a solid knowledge basis for the provision of public goods by European agriculture, so that ecosystem services are delivered efficiently and effectively.

The conceptual framework of this core theme highlights the following dimensions to this challenge:

- First, methods for assessing the role of agricultural systems for biodiversity and ecosystem services need to be benchmarked and improved; taking into account the variability in the physical and biological environment and in the land management at a range of spatial scales (e.g. farm, landscape and region).
- Second, further understanding of the trade-offs and synergies between agricultural practices, biodiversity and ecosystem services is required. Designing agricultural systems to provide a basket of ecosystem services according to demands by e.g. farmers and consumers could be studied by reverse engineering methods in a range of regional contexts. Increasing the use of functional biological diversity, of multi-component farming systems, of regulating services (e.g. auxiliaries, disease control by mixing cultivars...), of landscape scale management may foster the development of high nature value agricultural production systems (e.g., semi-natural grasslands), while increasing their resilience to climatic variability and extremes (see CT4).
- Third, land use planning strategies need to be evaluated, by comparing the 'land sparing' and 'land sharing' paradigms. *Land sparing assumes that 'intensive agricultural production will preserve ecosystems elsewhere', while land sharing assumes that 'multifunctional agricultural systems can accommodate production, biodiversity and ecosystem services'.* A European modeling of trade-offs in land use/management at a range of spatial and temporal scales is an overarching need.
- Fourth, evidence-based assessments of agri-environmental schemes are required, given that Common Agricultural Policy and a number of EC directives directly affect agriculture, biodiversity and ecosystem services. How to incentivise appropriate landscape design, and to increase resource use efficiency and ecosystem services through policy options is an important question for reducing trade-offs between food supply, biodiversity and ecosystem services in Europe.

Figure 6. Delineation of 6 cross-connected sub-themes for the core theme 3 'Trade-offs between food supply, biodiversity and ecosystem services'.



- Fifth, the impacts of imports and exports of agricultural commodities on land use change and land management outside Europe, especially in the developing world, should be considered. For instance, increased food insecurity and increased tropical deforestation may both take place through high food price levels that may be favoured by e.g. biofuel production. The role for biodiversity and ecosystem services of agricultural trade flows, which are also related to lifestyles and consumer behaviours (e.g. demand for meat), needs to be investigated. Implementing incentives and institutions for biodiversity and ecosystem services (including soil and land degradation, water rights), while preserving adjusted net savings from nature capital stock, is also a research goal (Figure 6).



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Strategic Research Agenda

Assessment of this core theme through mapping highlighted the following research needs:

- The need to define and establish **valuation methods for the ecosystem services** concept. The topic requires a horizontal view; therefore much effort has to be devoted to clarify concepts and approaches.
- An adequate assessment of ecosystem services through **spatial and temporal scaling**. Databases using previously defined parameters must be built by networking on demonstration areas (at a scale beyond the farm level) in order to address the optimisation of trade-offs between food production and other ecosystem services (biodiversity, landscape conservation...).
- **Interlinking between science and policy** should be viewed as the basis to pursue the optimisation of trade-offs among different ecosystem services.
- **Land sharing versus land sparing** is an issue to be taken into consideration to approach the sustainable intensification of food production and resilience of farming systems. A priority for research would thus be an evaluation of land use (land sharing vs. land sparing).
- **Food production versus mitigation/adaptation strategies**. Food production and optimisation of ecosystem services must take into consideration other relevant issues to cope with climate change. In this regard, adaptation strategies (risk assessment, regionalisation...) and mitigation initiatives (carbon sequestration, soil dynamics...) are crucial to adjust the trade-offs to future needs due to a changing environment.

Priority actions:

Short term	• Develop methods for assessing and monitoring biodiversity and ecosystems within agricultural landscapes across Europe and how these link to productivity and resource use efficiency and how they are to be valued by society and economically. • Create a training programme for young scientists on integrated approaches to functional biodiversity in an interdisciplinary context.
Medium term	• Biodiversity based low-input high productivity multi-component farming systems using e.g. within and between species diversity across trophic levels in combination with genomic selection and conventional breeding. • Create open access databases for ecosystem information (including food production), with the depositing of field and experimental data in the database as a prerequisite to funding. • Put in place a network among experimental farms at a large spatial and temporal scale involving scientists, policy makers and farmers. Within the network the approach for data collection should be standardised, data should be shared, and the network should yield data from different landscape and farm types.
Long term	• Adaptive management of high nature value agricultural landscapes producing specific products in high demand.

• • • • •
 • ✓ Planned joint actions: FACCE – JPI is working
 • with the BioDivERsA ERA-NET to develop a
 • call through discussions on research topics.
 • • • • •

Core theme 4:

Adaptation to climate change

This core theme includes:

- Adaptation to climate change and increased climatic variability throughout the whole food chain, including market repercussions;
- Tailoring adapted regional production systems under climate change;
- Adapting seeds and breeds through conventional breeding and biotechnology ¹² to new combinations of environment and management: e.g. abiotic stresses, elevated CO₂;
- Monitoring pests and diseases and developing climate-informed crop and animal protection;
- Adaptive water management in agriculture, watershed management, flood management, irrigation technologies, water re-use;
- Adapting food processing and retailing, markets and institutions to increased climatic variability and climatic change.

¹² Biotechnology here is used in a broad sense, referring to marker-assisted selection, genomic selection and genetic modification methods.

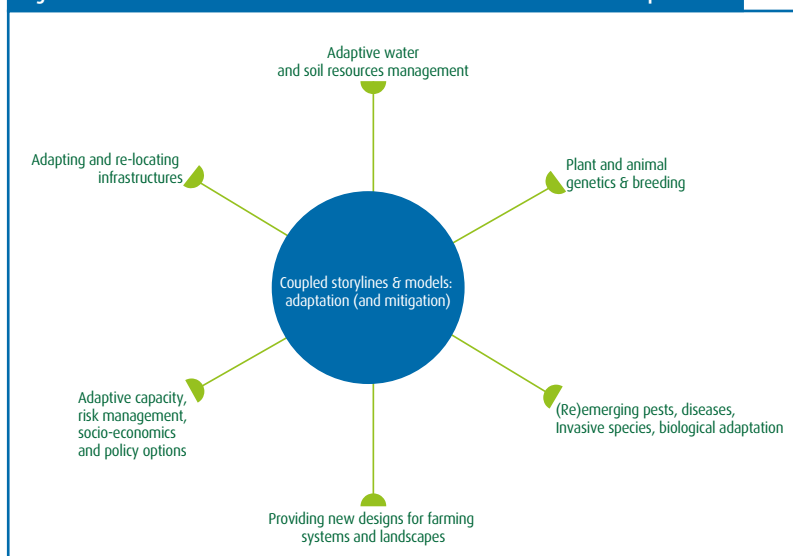
The conceptual framework of this core theme highlights the following dimensions to this challenge:

- Adaptation pathways, relating short-term and long-term options, need to be based on a detailed understanding of the risks and opportunities for agricultural and food systems in the context of climate change (see MACSUR network, CT1). Moreover, integrating adaptation (CT4) and mitigation (CT5) pathways and better understanding synergies and trade-offs is required.
- In the long term, the baseline for determining adaptation options will vary given other components of global change, such as increasing scarcities in fossil fuels and in natural resources, and altered markets and consumers' perceptions; such changes also need to be addressed in relation with CT1.

The adaptation core theme should be articulated with a number of complementary research goals:

- First, water and soil resources are exposed to multiple pressures under climate change. Adaptive water and soil management methods need to be developed at a range of interconnected scales (e.g. from the field to the watershed), taking into account the diversity of regional contexts in Europe.
- Second, biological adaptation to climate change is already taking place, e.g. through natural selection, biological invasions and emerging pests and diseases. Better understanding the associated risks and developing both preventive and palliative strategies is required.
- Third, a key challenge concerns plant and animal breeding. Preserving genetic resources, defining new breeding targets in response to elevated CO₂, to abiotic (e.g. high temperatures, water deficit, ozone, salinity, etc...) and biotic stresses (e.g. from emerging pests and diseases) and developing advanced infrastructures for plant and animal breeding appears as a key priority.
- Fourth, new designs for farming systems and for agricultural landscapes need to be provided by research in order to facilitate changes in land management in regions that are likely to undergo radical changes in the long term, given the risks and/or opportunities associated to climate

Figure 7. Delineation of 6 cross-connected sub-themes for the core theme 4 'Adaptation'



change and to other components of global change (such as the increased scarcities in fossil energy and in natural resources).

- Fifth, the adaptive capacity of European agricultural systems needs to be mapped and inter-compared in order to determine adaptation hot-spots, which are systems at risk given their high vulnerability and low adaptive capacity. Risk management tools and socio-economic and policy options will need to be prioritised for these regions and systems, taking into account however the uncertainties associated with climate change projections.
- Finally, adaptation of the food supply chains (including transportation, processing and retailing) also needs to be considered, by addressing the possible changes in the corresponding industries and their infrastructures (e.g. silos, slaughter houses, factories, etc...).

These six sub-themes of the adaptation CT should be coupled through the development of storylines and of scenarios, showing a range of pathways for adaptation that will support discussions with stakeholders and decision makers (Figure 7).



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Strategic Research Agenda

Assessment of this core theme through mapping highlighted the following research needs:

- **Animal health.** This should address the effects of climate change and the associated risks for animal health (including existing and emerging diseases). Dealing with increased risks will be dependent on mankind's efforts to adapt livestock systems, both in confined and pasture systems (the former also affected by climate change). Issues such as animal breeding for robustness, e.g. adaptation to heat and other extreme conditions, as well as breeding of fodder plants for better nutrient composition and higher production, also under abiotic stress conditions, should be taken into consideration. Changes in animal production may affect the release of greenhouse gases and therefore interact with mitigation efforts.
- **Crop research.** Strengthening of the following aspects is crucial: development of strategies on climate change adaptation for different kinds of crop production systems, from a comprehensive point of view; integrated and sustainable use of modern agronomy; plant breeding for adaptation; fertilisation; water, plant and disease management in relation with technological facilities; study of soil; development and improvement of science-based and environmentally friendly risk assessment-prevention-management systems and measures for climate change-driven pests on plants such as Integrated Pest Management (IPM); adaptation measures for future climate change in different regions, focusing on crop production and yields in relation with food security and optimised mitigation strategies.
- **Silviculture.** Adaptation of forestry to climate change includes aspects such as adaptation to longer growing seasons in the North, to changed ground water levels, to changed biodiversity potential, and to emerging diseases. Selection of species and varieties, tree breeding and forest management are areas for adaptation research.
- **Water management for agriculture.** Research efforts should focus on: water stress, dryness (desertification), flooding, quantity and quality of water and water management. Moreover it is very important to strengthen the strategies including water capturing, storing, and management, increasing the efficient use of water for climate change adaptation.
- **Risk assessment and Resilience to extremes.** To achieve climate smart agro-systems in Europe, supported by all partners in the Food Chain (farmers to consumers), there is need for a clear survey of the effects of extremes in climate changes on farming systems. They influence the resilience, and therefore the production, and finally the economic benefits of agro-systems (e.g. especially for the middle and long term period). In this respect a better understanding of the interrelations between ecological and social systems will increase the efficiency and adaptability of farming systems to unexpected changes. Moreover, more specific research on risk assessment is needed in order to qualify and to quantify the impact of climate change on our agro-systems, as this is crucial if we want to have tools and proofs to stress the importance of including climate change and climate adaptation in the political agendas of the EU and their Member States.

Cross-cutting issues:

- **Regionalisation:** measures have to be adapted to the special characteristics of each area. European regions, with their own topographic and geographic characteristics, demand different assessments on vulnerability of natural ecosystems, biodiversity, hydrology and water supply and socio-economic sectors in relation to climate change. Global, regional and local strategies need to be developed for climate change adaptation for different types of production systems.
- **Ecosystems and biodiversity.** Climate change affects ecosystems and biodiversity in an interconnected manner. Thus a holistic approach should be taken towards increasing food security while avoiding ecosystem damage and to create "win-win" solutions.
- **Socio-economic factors.** Societal factors play a critical role in the adaptation to climate change. Therefore it is necessary to foster the participation and involvement of all the stakeholders of society (especially farmers) on this topic. In order to do so, it is important to create different mechanisms and policies aiming to raise awareness on adaptation, foster financial incentives for environmentally friendly farming and increase the sustainability of consumer behaviours. On the economic side it is advisable to address adaptation matters using cost-benefit analysis and cross-sectorial approaches.

Priority actions:

Short term	• Design management relevant novel ideotypes adapted to climate change and elevated CO₂ and assessing groundbreaking designs for improving plant and animal productivity under climate change. • Strengthen the policy-driven research and the research supporting regulation on adaptation for a knowledge base underpinning the Common Agricultural Policy and the rural development policy. • Design and test methods for better water management for agriculture on farm level and landscape level (capture, store, precision use, preventing desertification and flooding).
Medium term	• Understand the adaptive value of diversity, specialisation and trade in European agriculture, through appropriate modeling. • Animal breeding for robustness (adaptation to heat and other extreme conditions, less sensitive to diseases) and reduced climate change impact (less greenhouse gas emissions) . • Impact assessment and strategy development against emerging pests and diseases (e.g. climate change- induced plant diseases).
Long term	• Epidemiological models and near real time climate-informed forecasts of pests (and their natural enemies) and diseases. • Regional scale strategies for preserving gene resistance against pests, diseases and pathogens in crop and animal species. • Stress tolerant (e.g., drought, heat, freezing, salt) productive crop species and thermo-tolerant animal species. • Sustain long term field trials and extend the use of climate change impact studies and effects of regionalisation.

- ✓ On-going joint action: ERA-NET Plus proposal
- •“Climate smart agriculture: adaptation of agricultural systems in Europe”
- • 12 M€ estimated contribution of the FACCE – JPI Member States
- • 4 M€ top-up contribution from the European Commission
- • 2013 call

Core theme **5**:

Mitigation of climate change

This core theme includes:

- Contributing to direct reductions of GHG emissions through carbon sequestration, substitution of fossil-based energy and products, and mitigation of N₂O and CH₄ emissions by the agriculture and forestry sector, while reducing GHG emissions associated with indirect land use change;
- Developing monitoring and verification methodologies of field, animal and farm scale GHG budgets, including, or not, indirect land use and cradle to grave life cycle;
- Developing verifiable GHG mitigation and carbon sequestration measures in farming systems;
- Developing technologies and methods to substitute fossil-fuel energy through increased use of biomass and other renewable energies in the agriculture sector without jeopardising food security.

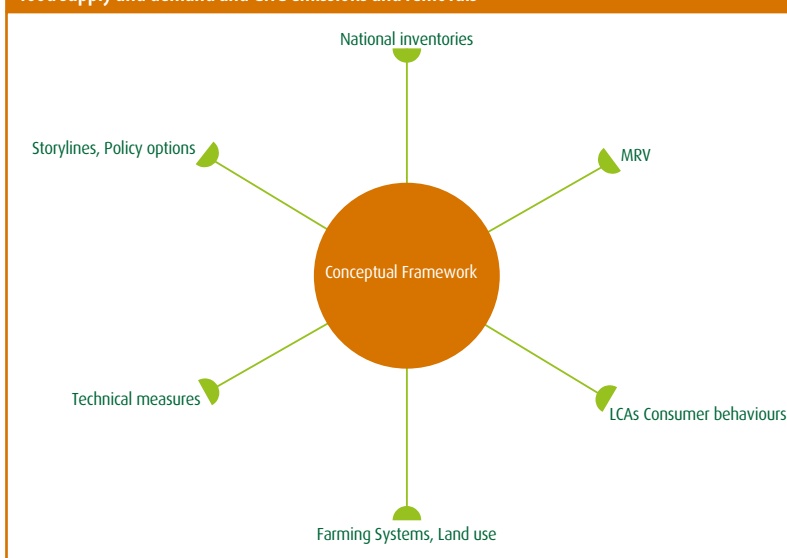
The conceptual framework of this core theme highlights the following dimensions to this challenge:

- The need to consider agriculture, forestry and land use change as a single sector when looking at biophysical estimates of mitigation potential. Bioenergy aspects (substitution of fossil fuels) are covered and accounted for as a different sector (energy) but need to be integrated to capture land based options for GHG mitigation.
- The European research infrastructure required to monitor, report and verify (MRV) GHG emissions and removals needs to be developed. Independent verification of national inventories is needed and can be achieved through the combination of inverse atmospheric modeling and of GHG flux measurements and modeling.
- Mitigation options should be accounted for by national inventories of GHG emissions and removals. National inventories therefore need to be improved, e.g. through the refinement of emission factors (i.e. Tier 2 methods) and through a certified modeling of GHG emissions and removals (i.e. Tier 3 methods). This will require a large and concerted R&D effort and will allow better understanding the baseline against which mitigation takes place.
- Barriers need to be elucidated when addressing the technical, economic and market potentials of mitigation options (economic and market areas are more difficult as these differ between countries and differ again in developing countries). Studies looking at the cost per tonne of CO₂ in implementing mitigation measures need to assess the costs and benefits both for the public (R&D, dissemination, training, regulatory measures) and for the private sector.
 - When considering GHG emissions and removals, system analysis needs to be further developed and applied to food supply and demand chains, including trade issues, processing and retailing, diets and waste, plus the complication of inter-sectoral emissions for example transport, buildings. The forestry sector raises particular issues regarding carbon storage and potential to use timber for fuel. Options concerning forestry and biofuels need to be better integrated and also linked to the opportunities for recycling biomass waste.
 - More social sciences are needed to understand the determinants of dietary choices (e.g., meat consumption) and the role of economic

and social factors and the role of policy options. Further development of scenarios and storylines for the world and for Europe will be required in this area.

- In conclusion, the following sub-themes (Figure 8) that are all related to a conceptual framework relating land use, food supply and demand and GHG emissions and removals were delineated: i) refinement of national GHG inventories to better account for mitigation options; ii) monitoring, reporting and verification of GHG emissions and removals (MRV); iii) system analysis of food chains, e.g. through lifecycle analysis (LCA) and consumer behaviour studies; iv) farm scale mitigation through changes in farming systems and in land use; v) development of technologies for on-farm mitigation measures aiming at an improved eco-efficiency; vi) storylines and policy options, including changing diets, processing and retailing and reducing waste.

Figure 8. Delineation of 6 cross-connected sub-themes for the core theme 5 'Mitigation'. These sub-themes are all related to a conceptual framework relating land use, food supply and demand and GHG emissions and removals





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Strategic Research Agenda

Assessment of this core theme through mapping highlighted the following research needs:

- **Mitigation options focusing on carbon sequestration in crop production.** The first aspect in this regard is sequestration in soil. This includes biological processes and agronomic management practices concerning soil carbon dynamics and sequestration. The other sub-theme is the efficiency of crops, grasslands and forests as carbon sinks.
- **Protocols and certification for methods to assess greenhouse gas emission.** Policy measures and (new) technologies should be based on sound evidence and the best knowledge available. Results from different research projects and trials should be comparable and available, including the underlying data. Harmonisation of assessment methods and working methodologies would not only contribute to the quality and comparability of the data, but also in a better judgement of the effects of (potential) measures to reduce emission of greenhouse gasses. Training and education courses were mentioned as a tool to stimulate methodology convergence.
- **Reduction of emissions by livestock,** in particular through nutrition and animal breeding. CH₄ and N₂O emissions are dependent on: i) animal species and breeds; ii) the housing system; iii) manure treatment; iv) diet composition and feeding regimes; v) soil management. These factors are interrelated. Low emission production systems are needed. Cheap and handy measurement tools are needed.
- **Carbon and nitrogen cycling in agro-ecosystems.** One possibility is to work toward a common framework for Life Cycle Analysis (LCA) of livestock production systems and of crop production systems, including investigation of how farming practices should be modified in order to optimise the management of crop residues and soils, and to increase carbon fixation. Finally, it is necessary to assess manure management and its role on climate change as well as, more generally, how carbon and nitrogen cycles are affected by climate change.
- **Study of indirect emissions.** This concerns quantification of indirect emissions (NO₃, NH₃), including nitrogen leaching, in the LCAs, and exploring the potential of precision agriculture to reduce nitrogen losses and increase nitrous oxide mitigation. A research priority would thus be to develop global, regional and local strategies for climate change mitigation adapted to production systems.

Cross-cutting issues:

- Adequate policies and their implementation are crucial for reducing agricultural GHG. These policies should be developed at the production system scale and be implemented at the regional level.
- Developing common databases is highly important but requires data produced using compatible protocols and standards.

Priority actions:

Short term	• Estimation of carbon sequestration capacity of agroecosystems and optimisation of verification methodologies based on surveys (e.g. soil surveys), remote sensing, management practices, process modeling, data streams (ICOS, Integrated Carbon Observation System) and novel technologies (e.g. neutron scattering). • Optimise cooperation between FACCE-JPI and the Global Research Alliance on Agricultural Greenhouse gases by using harmonised methods, common protocols, sharing of data and exchanging information on progress. • Start an open process to identify relevant infrastructures to study mitigation and map their location, the usability, and the costs/savings of sharing them. This includes farm and field measurements, lab equipment, and databases.
Medium term	• Assessment of the eco-efficiency of key farming systems within European sub-regions. • Technical and economical abatement potential of GHG mitigation measures and policy analysis. • Develop and undertake life cycle assessment to define the impact associated with agricultural practices at the farm level in frame of the development of adequate tools for judging emission scenarios/balances of integrated production systems.
Long term	• Abatement potential of changes in food systems, including approaches such as economics and sectoral policies, to be linked with adaptation above.

- ✓ On-going joint action: International call on mitigation
- "Mitigation of greenhouse gases"
- In collaboration with non-European GRA countries
- To be launched in 2013

Summary:

Main research issues in the five core research theme

The following Table 1 provides further details on how the core research themes cover each issue within the scope of the FACCE – JPI.

Major research issues to be addressed under each of the five core themes	a. Scenarios of global change & adaptive strategies	b. Food systems and food security	c. Land use & sustainable management of biodiversity and natural resources	d. Crops: production, health and breeding	e. Livestock: production, health and breeding	f. GHG mitigation and C sequestration by agriculture	g. Bioenergy and biofuels	h. Forestry as related to agriculture and food security
CT1 Food security under climate change	●	●	●					
CT2 Sustainable intensification of agriculture		●	●	●	●	●		
CT3 Assessing trade-offs between food supply, biodiversity and ecosystem services		●	●	●	●	●	●	●
CT4 Adaptation to climate change	●	●	●	●	●	●	●	
CT5 Mitigation of climate change	●	●	●		●	●	●	●

Delivery of the Strategic Research Agenda



Instruments

As stated above, a key goal of FACCE – JPI is to identify

1• Areas for which much research is being done in many JPI countries. These topics are of interest for future alignment, joint actions or instruments.

2• Areas for which research is carried out in a small number of JPI countries. These latter are topics for novel alignment activities (e.g. geographic, thematic).

3• Topics which are in the Strategic Research Agenda but on which there is little or no research. These topics could give rise to new topics in Horizon 2020 as collaborative projects, joint calls or ERA-NETs.

4• Emerging topics. FACCE – JPI will organise workshops, seminars or idea labs to further explore these topics.

Thus, participating countries will need to find new ways to work together to achieve harmonisation and streamlining of national research. JPIs are not solely about new joint calls for proposals, but aligning already funded national projects and programmes towards the common FACCE – JPI Strategic Research Agenda. In this way we can achieve the ultimate goal of JPIs to establish an ERA-approach to the societal challenge upon which our JPI is based. A top-level aim of JPIs is to ensure the European Research Area is achieved through national efforts in key societal challenges in addition to EU programmes.

This is illustrated in the first FACCE Knowledge Hub, which is an innovative, tailor-made instrument associating 3 complementary dimensions: networking, research and capacity building. The aims of a Knowledge Hub are to increase and facilitate cooperation between excellent researchers and research institutions; bring international impact, develop research capacity, provide learning and training activities and in the long-term to provide efficient scientific support for strategic and political decision-making. The Knowledge Hub is an early instrument for alignment, in which many participants are already (nationally) funded to carry out (national) research. This has also necessitated some additional research funding in some countries, which is of course beneficial.

To deliver the Strategic Research Agenda, additional “à la carte” programmes will be developed in which several countries in variable geometry participate voluntarily and on the basis of their respective political and financial commitments and strategies. The FACCE – JPI seeks to create a dialogue among the participating countries concerning the definition of new programmes.

This will also require more integrated links with the next common strategic framework programme for research and innovation of the European Commission (European Commission, 2011), Horizon 2020. Most importantly, interactions need to be promoted between researchers, farmers, private sector and consumers, in order to provide new opportunities for innovation. The FACCE – JPI will establish links with the new European Innovation Partnership on Agricultural Productivity and Sustainability. The development of this research will require increased access to research infrastructures as well as training and capacity building (see Horizontal Programmes and Activities, p. 38) in a number of disciplines which have been neglected over the past decades and that need to move toward more integrated systems approaches, by better integrating developments from a range of other disciplines such as ecology, earth sciences, social sciences, applied mathematics and computing.

Additionally, the use of existing EC instruments such as public – public partnerships (ERA-NETs, ERA-NET Plus or Article 185) or public-private partnerships, infrastructures, mobility and training grants will enhance the ability of participants to work together in the implementation of the FACCE – JPI Research Agenda for European added value. FACCE – JPI has presented topics where we had evidence that new research was needed to the European Commission for consideration to be included in the work programme for the final calls for proposals in FP7.

Although it is of utmost importance that the JPI delivers research of the highest quality, competition between countries is not always the most efficient way forward. For example, smart specialisation between Member States and research institutes will be explored. This could include specialisation with respect to research themes and research facilities. Since the FACCE – JPI will require a broad range of independent researchers from various sectors and with different backgrounds, this could be aided by the identification of the existing groups across the EU who are vertically integrated to the Core Themes and then a further phase of identification of the groups who can provide cross cutting technology or commercial capabilities to the Core Themes. Moreover, aspects of networking and capacity building shall be considered in every action (see Horizontal Programmes and Activities).

A balance between top-down and bottom-up approaches is necessary. The view of the scientific community towards how and on what subjects to implement alignment of national programmes should also be taken into consideration. The FACCE – JPI seeks new ways of working together, as in the Knowledge Hub, that allow researchers to collaborate and to share resources and data, rather than just competing.



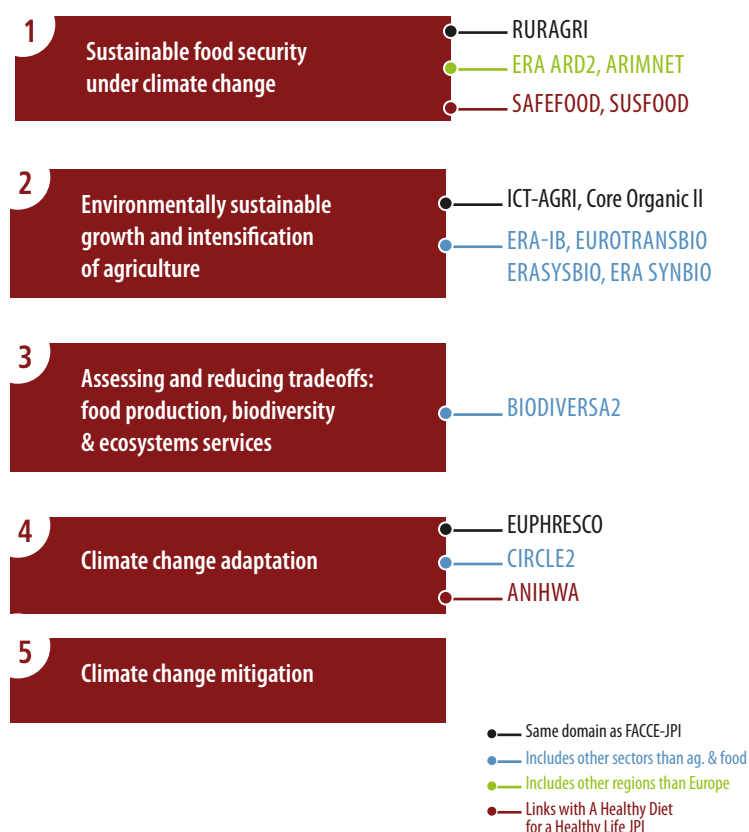
FACCEJPI

Strategic Research Agenda

Another means of implementing the Research Agenda is through ERA-NETs. FACCE – JPI is unique in that it is the only JPI with a large number of ERA-NETs with thematic complementarity (Figure 9)¹³ (see also annex 4). ERA-NETs are specialised to carry out transnational calls, and as such, may provide a means for partial implementation of the agenda of the FACCE – JPI. To this end, a first mapping of thematic complementarities has been undertaken by FACCE – JPI in a workshop (October, 2011) which brought together 14 ERA-NETs as well as representatives of the European Commission. Which shows the main core theme addressed by each ERA-NET, although some ERA-NETs concern more than one core theme. The objective of the JPI is to ensure coordination with a maximum of existing and new ERA-NETs so that the calls that they organise serve to implement the Strategic Research Agenda of the JPI.

Figure 9. Main thematic complementarities between the FACCE – JPI and the relevant ERA-NETs

Thematic complementarities between FACCE – JPI and 15 ERA-NETs as identified at the first FACCE- JPI /ERA-NET brainstorming workshop (Oct 5, 2011)



¹³ Among these ERA-NETs are ARIMNET, EUPHRESKO 2, CORE Organic 2, BioDiversa, ICT-AGRI, RURAGRI, ANIHWA, ERA-CAPS, ERA-ARD, SUSFOOD, ERA-IB, ERASysBio, ERASynBio, CIRCLE 2 and ForestErra.

Horizontal programmes and activities

This strategy will be supported by horizontal programmes and activities on infrastructure and platforms, capacity building, education and training, knowledge exchange and communication and dissemination.

Infrastructures and platforms

The research undertaken to achieve the objectives of FACCE – JPI will require strong links to world class research infrastructures, on the one hand for observation and measurements and on the other hand, for integrating and harmonising data and resources' collection and storage. Furthermore, the JPI will seek to establish standardised protocols and tools for modeling and data analysis. (see Figure 10).

As noted above, key European infrastructures need to be assembled in order to integrate scenarios, observations, experiments and models so as to develop and inter-compare agro-ecological and socio-economic projections while assessing their uncertainties.

The FACCE – JPI is identifying and establishing links to existing and emerging European research infrastructures, for example ANAEE, MIRRI, ICOS, ELIXIR etc., seeking interactions with the European Strategy Forum on Research Infrastructures (ESFRI) and will propose areas where new infrastructures or upgrades of existing ones are necessary. One example would be the development of a European Research Infrastructure for Agricultural and Environmental data and models contributing to sustainable food security under climate change, which would aim at integrating key datasets and at developing the provision of better research services and models for adapting agriculture to climate change, while mitigating greenhouse gas emissions and contributing to global food security. Another example could be a network of interlinked long term observatories at field or catchment scales (e.g. for carbon sequestration and GHG emissions), able to supply robust databases which are essential for calibrating and validating biophysical models, under a wide range of EU conditions. A third example could be a network of long-term field trials that integrate climate change impact studies and effects of regionalisation.

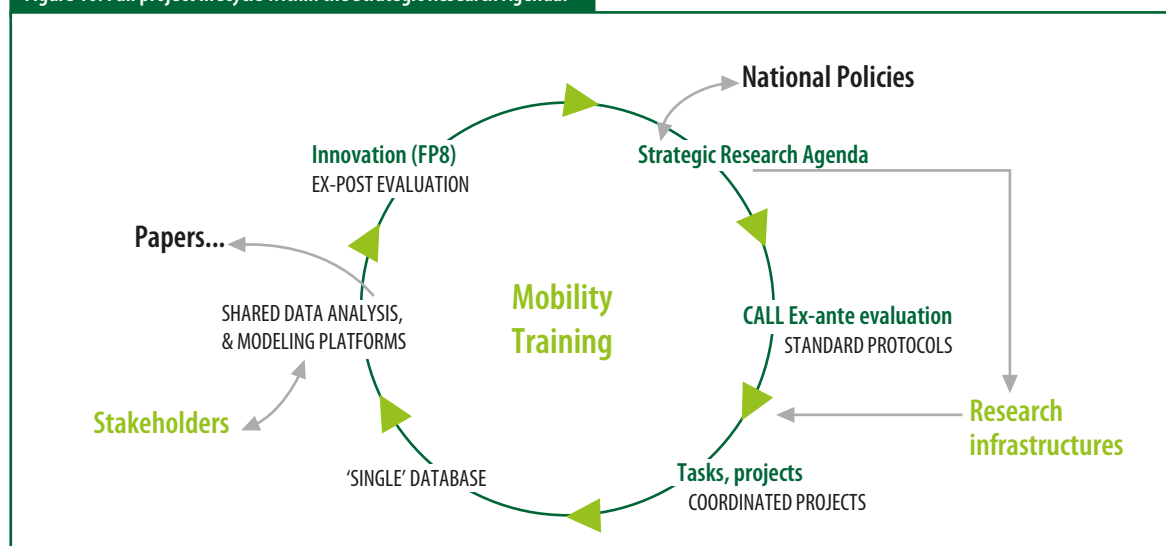
Protocols and data

There is an urgent need for harmonisation of methods and protocols as well as modeling systems and common databases (see Figure 10). Although there has been much progress, the development of common protocols is required for obtaining comparable data, needed to achieve a first critical step towards common databases. Examples include the need for common protocols for measurements of key processes (e.g. carbon sequestration, greenhouse gas emissions) at field scale, development of protocols for climate model downscaling and the development of sound databases useful for Life Cycle Assessment in agricultural systems. These tools are essential to enhance sharing and dissemination of information and new knowledge.

Sharing databases and modeling platforms

In addition to harmonisation of methods and protocols, the success of FACCE – JPI will depend on the sharing of data and databases, with

Figure 10. Full project lifecycle within the Strategic Research Agenda.



clear rules concerning intellectual property management. Mapping of existing databases could be a first step. Before resorting to new tools, existing databases could be shared, for example ClearingHouse, CIRCLE-2 INFOBASE, the ICT-AGRI tool MKB (Meta Knowledge Base). Sharing could be accomplished through research consortia or projects, workshops and networks.

In order to share data and databases, common formats are necessary. Another issue is the “homogenisation” of datasets and their quality control, implying the definition of clear protocols for data sharing which reduce ambiguity or bias.

Moreover, it is necessary to harmonise modeling systems and efforts. Models, e.g. for farm systems, should be compatible with each other (compatible protocols). This subject should be addressed together with related research initiatives. Harmonising modeling systems and efforts will be addressed in the FACCE – JPI Knowledge Hub, MACSUR: Modeling European Agriculture with Climate Change for Food Security. Finally, there is a need to ensure that activities of FACCE – JPI and the other global initiatives like the GRA should be complementary, using harmonised methods, common protocols, sharing of data and mutual information.

► Education, training and capacity building in Europe

The need for further strengthening of a number of disciplines (e.g. agronomy and animal husbandry, farming systems) has emerged in recent stakeholder interactions, which have also highlighted that European farmers and growers are getting older (only 7% are under 35, and 32% are over 65) and that recruitment to plant breeding courses in Universities and other academic institutions throughout Europe is declining. This poses a sustainability challenge to the European plant breeding and seeds businesses. To revitalise the agricultural sector, stakeholders are advising that a new generation of researchers and trained farmers and growers is needed.

FACCE – JPI will seek to promote education and training in planned joint actions by encouraging mobility of researchers in Europe at all levels to foster transfer of knowledge, organising Europe-wide research seminars to foster creative thinking and cross-disciplinary exchange of ideas, and organising workshops or training programmes around particular research themes, open to young researchers.

In view of the unequal research capacities in Europe, in addition to the above-mentioned actions, FACCE – JPI seeks to build research networks and to enhance networking between disciplines and research groups, within countries and at a European level. This is already being carried out in the first FACCE Knowledge Hub on modeling of impacts of climate change on European agriculture, called FACCE MACSUR.

► Knowledge exchange

Interactions need to be promoted between researchers, farmers, and the farming industry, private sector and consumers, in order to provide new opportunities for innovation. FACCE – JPI will not only focus on research but also on innovation. Here, the importance of Small and Medium Enterprises (SMEs) and industry in the agriculture and food sectors has to be stressed, including their role in fostering societal innovation and shaping consumer behaviour. Instruments to improve access to innovation as well as specific innovation activities are essential in this domain. FACCE – JPI will seek further interactions with stakeholders before planning this approach.

Specifically, the need to link outcomes of climate change risk assessment to the researchers/practitioners who will need to respond (e.g. crop breeders, disease researchers, land management expertise) has already been highlighted as a potential priority by members of the Stakeholder Advisory Board. There is a need for integration of innovative and sustainable agricultural dynamics in the upstream and downstream sectors. Specific means include institutional innovation,



FACCEJPI

Strategic Research Agenda

"research-actions", i.e. the co-construction of new production systems with farmers and transposition of existing innovations (i.e. reuse or generalisation, with possible adaptation of innovative approaches which already exist) and setting up a catalogue of techniques available online (not restricted to techniques presently in use, but encompassing the whole "book of blueprints" which constitutes the original concept of a production function in economy).

► Communication and dissemination

FACCE – JPI seeks to foster communication between the scientific community, policy makers, stakeholders/end users and funders. This is done primarily through the web site: www.faccejpi.com.

In order to foster the participation in FACCE – JPI actions and uptake of research results coming from the FACCE – JPI, it is crucial that all actors be informed of research actions and their outcomes and also that relevant stakeholders have input into critical research needs. Dialogue must be promoted between researchers, policy-makers and stakeholders/ end-users (farmers, agri-food industry).

Communication will aim to increase awareness of the challenges that the agri-food sector is facing now and in the future. It will further encourage researchers and relevant funding agencies to become involved in the JPI and its activities.

• Research community

FACCE – JPI recognises the need to communicate within the research community on FACCE – JPI actions and outputs. There is a need to publicise the JPI and its activities among researchers, perhaps through international conferences or seminars, through the web site and newsletter and by using modern communication technologies. The Scientific Advisory Board has a key role in the communication and interactions with the research community and, when appropriate, in seeking their input. It is particularly important that FACCE – JPI actions are announced largely, and in advance, to the relevant researchers, and that their participation is encouraged.

• Stakeholders

A need to communicate and form links with stakeholders, in the broadest sense, is highlighted. This includes companies and especially SMEs, so that they can take up the research findings toward innovative products, practices and services, European Technology Platforms, all sectors of the bioeconomy web, farmers and the farming industry, including extension services (see also below) and NGOs.

Communication with key stakeholders will also be achieved in part through the Stakeholder Advisory Board, which brings together representatives from 22 European and international organisations.

Further interaction with stakeholders will be carried out through further consultations, as the one conducted in January – March, 2012 or through targeted workshops.

Through the Stakeholder Advisory Board, links will be made to farmers and the agri-food industry. The aim of the Stakeholder Advisory Board is to accompany the FACCE – JPI process from a stakeholders point of view, including input into proposals for priorities for short-, medium- and long-term joint actions of the FACCE – JPI, contributing actively to the continuing elaboration of the Strategic Research Agenda as well as providing advice on its implementation, e.g. training, infrastructure, knowledge exchange.

• Policy dialogue

The problems related to agriculture, food security and climate change require a European-wide long-term research base. This research will inform national and European policy makers and will highlight current and emerging issues. It is critical that policy be evidence-based. It is thus necessary to strengthen the policy-driven research and research supporting regulation on JPI issues, e.g. for a knowledge base underpinning the Common Agricultural Policy. The FACCE – JPI will examine the best policy mechanisms to achieve its objectives.

The research from the FACCE – JPI can contribute to EU and national policies concerning food security and climate change and this policy dialogue will undoubtedly be necessary for the FACCE – JPI research to have an impact on the global challenge. The question of how the research produced will be taken up by policy makers, researchers, land managers is important and greater emphasis could be given to research focusing on the best policy mechanisms to achieve the objectives set out by the FACCE – JPI. On the other hand, the research areas covered by the JPI deal with large uncertainties and thus it is important to consider how to communicate uncertainty to policy makers who generally want to know the 'right' answer or the 'correct' number. Another point concerns the effects and consequences of different agreements, policies and laws on agricultural production and land use.

Concretely, a mid-term priority for the JPI could be to invest on research-policy interfaces and interdisciplinary approaches at the case-study scales, i.e. the development of a network of case-study scale observatories for experimenting new modalities for connecting researchers, policy makers and other stakeholders.

• Funders

Through the participation of representatives of funding agencies in the Governing Board and mapping meetings, a dialogue with funders has been initiated. Other local, regional, national and international initiatives exist or are going to be created, whose objectives overlap those of

FACCE-JPI. These challenges have to be considered on a global basis, namely because of the very strong inter-relation between regional climates, but can only be effectively handled on a more local basis. Where relevant, the use of regional initiatives is essential for tackling these challenges in addition to cooperation with global initiatives. This implies a need to define a strategy for involving national and sub-national funding agencies in addressing efforts in the context of the FACCE issues. Further, FACCE – JPI must incite all EU researchers and funding agencies to develop research activities that are consistent with the FACCE priorities, protocols and approaches.

FACCE – JPI will build on achievements across Europe to date, notably interactions, cooperation and coordinated approaches with various actors such as The Standing Committee on Agricultural Research (SCAR).

Evaluation and monitoring

Individual joint actions and any corresponding funding procedures will be monitored and evaluated to ensure optimal implementation in the FACCE – JPI process as well as informing future activity. For joint actions, the procedures for setting up the joint action will be evaluated (e.g., availability of information on the call, electronic submission system, eligibility check, evaluation process, informing of evaluation outcomes) as well as the progress of the accepted projects (scientific and financial reporting, scientific outcome in the form of papers, patents, etc. plus impact on the societal challenges). Moreover, the JPI process will be monitored and evaluated to ensure that FACCE – JPI is fulfilling its objective of aligning national research programming in Europe and contributing to a European Research Area to bring greater impact of European research toward addressing the societal challenge of food security in the face of climate change. The impact of FACCE – JPI on policy-making in Europe will also be assessed. A set of indicators will be developed that take into account FACCE – JPI objectives, activities, outputs, outcomes and impacts. FACCE – JPI Advisory Boards (SAB and StAB) as well as external experts will be called upon to participate in evaluation activities.

Conclusion

Joint Programming is a pioneer concept.

As a long term strategic process, JPIs are initiatives designed to shape the future European Research Area. They are expected to enhance European competitiveness by pooling national resources and avoiding

fragmentation and duplication of research efforts. Moreover, JPIs will provide the research base needed to inform European policies on issues of great societal importance, in the short and long term, using existing instruments and with the willingness to invent new tools and ways of working together.

Joint Programming is an evolving process. This agenda marks a milestone in the process toward addressing these challenges as well as a fully integrated European Research Area.

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Annexes



Annex 1: Scope of the FACCE – JPI

Agriculture. Agriculture can be defined in a broad sense as the production of food, feed, fuel and fibre by land based systems. Thus, the sector includes annual and perennial crops, grasslands, livestock and forestry, rural landscapes, land use, biodiversity and ecosystem services. Freshwater and marine aquaculture are also included because feed production is required as input to these systems. Marine fisheries are not considered within the scope, since these will be addressed by the 'Healthy and productive seas and oceans' JPI. Competition for land will grow and it is important to focus on the sustainable intensification of production and, at the same time, consider ecosystem services that agriculture can offer, as well as linkages with the broader bioeconomy¹⁷. Bioenergy, biofuels and biomaterials are included as they will become even more important as prices of fossil-based energy and raw-materials rise and as the environmental and security risks associated with dependence on fossil fuels are recognised.

Food security. Agricultural production is not the only component determining people's food security. The UN-FAO World Food Summit 1996 created a definition, which is used in the context of the JPI: 'Food Security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life'. The JPI will highlight supply and utilisation of food with less research on processing, packaging, distribution, retail and economic access. The JPI will also embrace the safety aspects of food security, as defined above, and the agricultural and food policies that impact on food safety and nutrition. Further, the JPI will map and monitor emerging technologies that impact on agriculture and food security. However, the FACCE JPI will not include issues covered by the 'Healthy food for healthy life' JPI, such as: the determinants of diet and physical activity; eating habits and diet advice and diet-related chronic diseases.

Climate change. The future of agriculture and of food security will take place under climate change and under other global environmental changes¹⁸. The JPI, while considering climate change in a global and regional context, must develop scientific understanding to assist European Union farmers in adapting locally to climate variability and climate change, and to ensure that EU farming and food systems contribute to reducing greenhouse gas emissions. The link between the global, European and local farm levels necessitates that scaling issues are addressed early on in the programme. Collaborations with the climate research community¹⁹ need to be organised. Since many mitigation efforts can also assist in adaptation it is important to integrate the two, taking into account regional variation across Europe. Links will be made to the Climate JPI as well as the Global Research Alliance on Agricultural Greenhouse Gases to avoid overlaps and provide complementarity.

Water. Special attention should be paid by the FACCE – JPI to water management in agriculture, since about 70% of the global freshwater pre-empted by human use is allocated to agriculture. Adaptive water management in the context of climate change, increasing demands from non-agricultural sectors and limited water supply needs to be developed by research targeting water use efficiency in both rain-fed and irrigated agriculture and reduction of yield loss from water deficits. Links will be made to the water JPI to avoid overlaps and provide complementarity.

Land use. Today, approximately 12% of the Earth's land area is under intensive crop production and close to 20% is pasture and rangeland used for livestock production. Future land use on Earth must accommodate multiple competing demands for food and fibre, energy, services, infrastructure and conservation by some 9 billion people – on a non-expandable global surface. There is a need for integrative, systems-level research approaches by the JPI to address changes in land use both in Europe and at a global scale, in link with climate change and with food security.

Scope of the economic and social approaches. Integration of economic approaches and expertise will be important in developing FACCE-JPI. Economics is of importance for identifying research priorities and innovation opportunities, as are social attitudes, consumer preferences, risk management, international trade, employment and institutional issues, etc, given their direct relevance to climate change and food security. Other social sciences (such as sociology, policy sciences etc...) may also be required. This will necessitate a sound consultative process across disciplines.

Scenarios of global change and time horizon. Current climate research efforts (Intergovernmental Panel on Climate Change, 5th Assessment Report) start from atmospheric GHG concentration pathways to generate new socio-economic and climate scenarios, which can be used for integrated assessments of impacts, adaptation, mitigation and vulnerability. The proposed Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) will develop biodiversity scenarios beyond those initiated by the Millennium Ecosystem Assessment. For agriculture and food security, important areas include the development of contrasted future agricultural scenarios and storylines, upgrade of models (including biophysical, biological, economics) and ensemble modeling for risk assessment. Most climate modeling considers timescales of 50–100 years, but increasing attention should be given to shorter-term seasonal/decadal predictions. Therefore a JPI time horizon of a few decades is proposed, perhaps until 2050. Time horizons will also dictate the geographical scope needed – for example 2050 would need a global horizon, but shorter timescales over the next 3–5 years could focus on the EU.

Geographical scope. The focus is on Europe, but Europe is part of a global system of food production and consumption. The research agenda of Europe in the food, agriculture and climate change domains has impacts on the global research capacities and creates potentially important spill-over effects to other regions of the world. Thus, the JPI must consider Europe's role in a global context and how the global context will affect Europe. For FACCE – JPI it is proposed to cover the role of Europe for sustainable resource (land and water) use and for European and global food security. A complementary focus on food security and climate change impacts on surrounding regions (e.g., the Mediterranean Basin) and on outside Europe (e.g., in Sub-Saharan Africa) is recommended and could be carried out through collaborations with other countries and with international programmes, such as the Climate Change, Agriculture and Food Security (CCAFS) of the CGIAR. The JPI will greatly advance the study of agriculture in developed countries for global food security and this will complement CGIAR international efforts which are currently centred on developing countries.

¹⁷ The usual definition of bioeconomy includes biorefinery as part of agricultural processes which can be included in the FACCE JPI. However, the corresponding industrial processes are not within the scope.

¹⁸ Rate of biodiversity loss, saturation of the nitrogen and phosphorus cycles, stratospheric ozone depletion, global freshwater use, change in land use, atmospheric aerosol loading and chemical pollution (Rockström et al., Nature, 2009)

¹⁹ World Climate Research Programme (WCRP) of the World Meteorological Organization (WMO), International Council for Science (ICSU) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, 'Connected Climate Knowledge for Europe' JPI.



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Strategic
Research
Agenda

Annex 2: FACCE – JPI Governance and membership

Annex 2.1: Permanent governance

For the permanent governance document, please refer to the FACCE – JPI website:
<http://www.faccejpi.com/Governance>

Annex 2.2: GB membership

Chair: Marion Guillou (FR)

Vice-Chairs: Marina Montedoro (IT), Niels Gøtke (DK)

COUNTRY	LAST NAME	FIRST NAME	INSTITUTE
Austria	HELGENBERGER FUHRMANN	Sebastian Elfriede	University of Natural resources and Applied Life Sciences Federal Ministry of Agriculture, Forestry, Environment and Water Management
Belgium	VUYLSTEKE VAN CAUWENBERG	Anne Thierry	Flemish Government Department of Agriculture and Fisheries Département des Programmes de Recherche Direction des programmes fédéraux et internationaux
Cyprus	ANTONIOU CHRYSAFI	Leonidas Rebecca	Research Promotion Foundation Research Promotion Foundation
Czech Republic	JERABEK	Ladislav	Ministry of Agriculture of the Czech Republic
Denmark	GØTKE	Niels	Ministry of Science Technology and Innovation
Estonia	KAARE	Küll	Estonian Ministry of Agriculture – Research and Development Department
Finland	PELTONEN ROOS	Mikko Jaana	Ministry of Agriculture and Forestry, Department of Agriculture AKA – Academy of Finland
France	GUILLOU HERAL	Marion Maurice	INRA ANR
Germany	LAMPEL RUDT VON COLLEBERG	Stefan Wiebke	Projekträger Jülich Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (BMELV)
Ireland	HOWELL O'MARA	Richard Frank (Prof.)	Ministry of Agriculture TEAGASC
Israel	ESH DAT KAPULNIK	Yuval Yoram (Prof.)	Ministry of Agriculture and Rural Development Agricultural Research Organization from the Volcani Center
Italy	MONTEDORO CINQUEPALMI	Marina Federico	Ministero delle Politiche Agricole e Forestali Ministry of Education, University and Research – Miur
The Netherlands	WIJERING DIJKHUIZEN	Annette Aalt	Ministry of Economic Affairs, Agriculture and Innovation WAGeningen UNIVERSITY RESEARCH
Norway	DANIELSEN RIBE	Kristin Harald	The Research Council of Norway, Dept. Agriculture and Marine Issues Norwegian Ministry of Agriculture and Food
Poland	RZEPECKA	Monika	Ministry of Science and Higher Education
Romania	BELC POPESCU	Nastasia Antoaneta	National Authority for Scientific Research National Authority for Scientific Research
Spain	MELGAREJO DURAN	Paloma Nuria	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA) Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)
Sweden	KÄLLMAN SVENSSON	Stefan Jan	Ministry for Rural Affairs Formas
Switzerland	WALTHER AESCHLIMANN	Pascal Andreas	Swiss National Science Foundation Forschungsinstitut Agroscope
Turkey	ADALI CELIKKANAT OZAN	Cinar Didem	Scientific and Technological Research Council of Turkey Scientific and Technological Research Council of Turkey
UK	WILLIS ROPER	Tim Mike	BBSRC Defra
OBSERVERS			
European Commission	HALL CONSTANTIN	Tim François	European Commission European Commission
SCAR	COLLINS	Mike	SCAR Representative, Department for Environment, Food and Rural Affairs (Defra)

Annex 2.3: SAB membership

Chair: Dr. Jean-François Soussana, INRA, FR

Current members		
Dr.	Harry Clark	Greenhouse Gas Research Centre, New Zealand
Prof.	Elias Fereres	School of Agricultural and Forestry Engineering, University of Córdoba, Spain, Institute of Sustainable Agriculture, Scientific Research Council of Spain (IAS-CSIC)
Prof.	Maggie Gill	Rural and Environment Research and Analysis Directorate, Scottish Government, UK
Prof.	Peter Gregory	University of Reading, UK
Prof.	Stephen P. Long	University of Illinois, Urbana-Champaign, USA
Mrs.	Rajul Pandya-Lorch	IFPRI, Washington DC, USA
Prof.	Pirjo Peltonen-Sainio	MTT Agrifood Research Finland
Prof.	John R. Porter	University of Copenhagen, Denmark
Prof.	Thomas Rosswall	CGIAR Program 'Climate Change, Agriculture and Food Security'
Dr.	Jean François Soussana	Institut National de la Recherche Agronomique (INRA) Paris, France
Dr.	Joachim von Braun	Center for Development Research (ZEF), University of Bonn, Germany
Former members		
Prof.	Kenneth Cassman	University of Nebraska, USA
Prof.	Frits Mohren	Centre for Ecosystem Studies, Wageningen University, Netherlands
Prof. Dr.	Bernd Müller-Röber	Potsdam University's Institute of Biochemistry and Biology, Max Planck Institute of Molecular Plant Physiology, Germany
Prof.	Johan Rockström	Stockholm University, Sweden
Dr.	Henning Steinfeld	Food and Agricultural Organization (FAO)

Annex 2.4: StAB membership *

Chair: Tania Runge, COPA-COGECA

Vice-Chairs: Beate Kettlitz, FoodDrinkEurope

Marco Schlüter, TP Organics

Dawn Howard, FABRE-TP

Organisation's name	Contact	Position
Climate Action Network	Emily Lewis-Brown	Research Manager - Compassion in World Farming
COPA-COGECA	Tania Runge	Recherche agricole et environnementale
European Initiative for Sustainable Development in Agriculture (EISA)	Robby Schreiber	Head of Brussels Office
European Council of Young Farmers	Pascale Rouhier	Secretary General
European Association for Bioindustries (Europabio)	Carel Du Marchie Sarvaas	Secretariat Agri-Food Council
FoodDrinkEurope	Beate Kettlitz	Director Food policy, science and R&D
European Crop Protection Association (ECPA)	Friedhelm Schmider	Director General
Plants for the future (ETP)	Silvia Travella	Coordinator
Sustainable Farm Animal Breeding and Reproduction Technology Platform (FABRE-TP) (ETP)	Dawn Howard	Director
The Forest-based sector (FTP)(ETP)	Johan Elvnert	Manager
Global Animal Health (ETPGAH) (ETP)	Declan O'Brien	Chairman, Executive Board
TPOrganics (ETP)	Marco Schlüter	Director of the secretariat
European Biofuels Technology Platform (EBTP)(ETP)	Lars Christian Hansen	Chair
Water Supply and Sanitation Technology Platform (WssTP) (ETP)	Durk Krol	Director
European Federation of Biotechnology	(EFB) Marc van Montagu	EFB President
European Association of Agricultural Economists (EAAE)	Alan Matthews	President of Board
European and Mediterranean Plant Protection Organization (EPPO)	Emanuelle Soubeyran	Head of EPPO France
International Organization for Biological and Integrated Control of Noxious Animals and Plants (IOBC-WPRS)	Franz Bigler	President of Executive Committee
European Animal Task Force	Paul Vriesekoop	Chairman
Global Research Alliance on Agricultural Greenhouse Gases (GRA)	Hayden Montgomery	Representative of the Alliance Secretariat
European Federation of Food Science & Technology (EFFoST)	Dietrich Knorr	President
European Regions Research and Innovation Network (ERRIN)	Francesca Ricardi di Netro	Veneto Agricoltura

* Some organisations invited to the STAB declined the invitation.



FACCEJPI

Strategic Research Agenda

Annex 3: FACCE – JPI meetings since 2010

Governing Board Meetings:

January 27, 2010
April 8, 2010
September 21, 2010
December 17, 2010
March 9-10, 2011
June 16, 2011
November 17, 2010
February 9, 2012
June 12, 2012
October 25, 2012
March 6, 2013

Scientific Advisory Board Meetings:

June 10, 2010
September 16, 2010
December 1, 2010
February 15, 2011
July 28-29, 2011, *Ad hoc* writing meeting
October 26, 2011
February 21, 2012 (*ad hoc*)
April 3-4, 2012
September 11-12, 2012
March 12, 2013

Stakeholder Advisory Board:

September 28, 2012
March 13, 2013

Secretariat meetings:

April 8, 2011
July 8, 2011
September 16, 2011
January 12-13, 2012
April 2-3, 2012
May 10-11, 2012
July 19-20, 2012
September 13-14, 2012
December 13-14, 2012

CSA:

April 14-15, 2011: CSA kick-off meeting
October 6-7, 2011: CSA meeting in Paris
April 26-27, 2012: CSA meeting in Bucharest
October 8-9: CSA meeting in Paris
January 17-18, 2013

Mapping meetings:

June 20-21, 2011 – Core theme 5: Climate change mitigation
February 22-23, 2012 – Core theme 4: Adaptation to climate change
July 11-12, 2012 – Core theme 3: Assessing and reducing trade-offs between food supply, biodiversity and ecosystem services
October 17-18, 2012 Core theme 1: Sustainable food security under climate change
April 10-11, 2013 Core theme 2: Environmentally sustainable growth and intensification of agriculture

Workshop on working with ERA-NETs:

October 5, 2011 in Paris

Workshop on outreach with international initiatives:

July 13, 2012 in Dublin

Workshop Group on methods for mapping:

April 28, 2011

Working Group on Alignment:

September 6, 2012 in Copenhagen

Pilot Action: Knowledge Hub preparation:

November 17, 2010, Berlin (Working Group)
February 1, 2011, Oslo (Working Group)
May 6, 2011, Berlin (Working Group)
July 13, 2011: Opening of call
September 7, 2011: Deadline for Letter of Intent
October 18, 2011: Networking meeting, Berlin
December 19, 2011: Deadline for submission of full proposal
January 26, 2012, Berlin: Meeting of Evaluation Committee and Steering Committee
April 11, 2012: Official funding decision
June 1, 2012: Official starting date of Knowledge Hub MACSUR
October 15-16, 2012: MACSUR Kick-off meeting

International Call on Mitigation:

January 16, 2012: Teleconference of Working Group
February 21, 2012: Meeting of working group, Madrid
December 4, 2012: First Steering Committee Meeting

ERANET Plus:

July 4, 2012: Information meeting in Brussels with Jörg Niehoff from EC
September 24, 2012: First consortium meeting in Paris

Call with Belmont Forum

December 17-19 2012: Scoping workshop

Annex 4: Thematic complementarities between FACCE – JPI and ERA-NETs

Below each core theme are the main ERA-NETs with thematic complementarities.

Core theme 1: Sustainable food security under climate change, based on an integrated food systems perspective: modeling, benchmarking and policy research perspective.

SUSFOOD's goal is to reinforce the scientific cooperation between EU member and associated states in order to maximise the contribution of research to the development of more sustainable food systems:

- 1• responding to the increasing demand for food to be met by increasing production sustainably and reducing losses and waste
- 2• mitigating the impact on the environment
- 3• combating obesity, malnutrition, and under-nutrition
- 4• reducing inequalities between rich and poor individuals and populations
- 5• improving the European agribusiness's competitiveness.

The scope of SUSFOOD encompasses the entire food supply chain with main focus on food chain sustainability beyond the farm gate, taking account of work pre-farm gate developed in other initiatives. It will cover processing, packaging, transport, retailing, food services, storage and consumer activities. It promotes a multi-disciplinary approach, from biology to food engineering, and social sciences. (Also concerns CT3 and CT5 marginally).

ARIMNET focuses on strengthening cooperation in Agricultural Research among Mediterranean countries through sharing priorities to enable them to respond more efficiently to the global challenges their agricultures are facing: sustainable development, natural resources management (mainly water and soils) and food security under the constraint of climate change.

ERA-ARD-II is working on Agricultural Research for Development. Strategic activities will focus on the exploration of possible convergences and synergies between developmental agricultural research programmes and European agricultural based research programmes.

CIRCLE 2 (see below) is marginally related to this core theme.

Core theme 2: Environmentally sustainable growth and intensification of agricultural systems under current and future climate and resource availability.

RURAGRI addresses core themes 2 and 3 and focuses on the following areas:

- 1• Ecosystems and Public Goods
- 2• Rural Socio-economic issues
- 3• Land use management

ICT AGRI addresses the advancements in ICT and robotics that are needed to facilitate the implementation of a green bio-production.

Main themes being addressed

- 1• precision agriculture / precision crop farming/ precision livestock farming
- 2• agriculture environment management
- 3• agriculture product quality sensing and documentation
- 4• agricultural decision support systems
- 5• data processing / integration of technologies
- 6• robotics, automation and machine control

CORE ORGANIC II: organic agriculture and food systems, especially ways to improve so-called "eco-functional intensification" in crop and livestock, how to secure food quality including careful processing and how to improve consumers trust and marked demands.

Specific topics include:

- 1• sustainable production of high quality food,
- 2• reducing dependency on high energy inputs,
- 3• improving environment and nature conservation,
- 4• climate change adaptation,
- 5• animal welfare as well as rural livelihoods
- 6• eco-functional intensification

ERA-CAPS will promote the creation and coordination of sustainable transnational plant science research programmes to meet the global challenges of food security and sustainability.

ERA-IB covers the so-called White Biotechnology or Industrial Biotechnology (IB), i.e. the modern use of biotechnology for the sustainable processing and production of chemicals, materials and fuels by way of enzymes and micro-organisms. IB is thus relevant to a wide range of sectors from chemistry, food and feed over paper and pulp to textiles and energy.

ERA SYSBIO concerns systems biology with application in biotechnology, biomedicine and agri-food.

ERASYNBIO: Areas for potential synergy identified related to this core theme were:

Crop plants with novel properties e.g. regarding efficiency, uptake of fertiliser



FACCEJPI

Strategic Research Agenda

EUPHRESKO and ANIHWA are marginally related to this core theme (see below).

Core theme 3: Assessing and reducing trade-offs between food production, biodiversity and ecosystem services.

BiodivERSA concerns high-level biodiversity research on a transnational scale. The currently open call is on "Invasive Species and Biological Invasions".

Discussions with FACCE – JPI on the future call of BiodivERSA have been initiated.

ARIMNET, CORE ORGANIC II and RURAGRI are also related to this core theme (see above).

EUPHRESKO, ANIHWA, and SUSFOOD are marginally related to this topic.

Core theme 4: Adaptation to climate change throughout the whole food chain, including market repercussions.

CIRCLE 2: The Climate Change Adaptation Agenda (CARA) addresses

1• Geographical issues: (1) Nordic area, (2) Mediterranean area and (3) Mountain areas.

2• Topical issues: How to deal and communicate) Uncertainties, Coast Water, Climate Data User Needs, Responses to extreme water related events, Forest (fires) and Adaptation in practice.

Discussions on Responses do Extreme water related events are being initiated with the involvement of FACCE – JPI.

EUPHRESKO

The common area of interest identified was the impact of climate change on plant health and specifically:

1• Identification of suitable indicators for influence of climate change on plant health

2• Development of a monitoring network to generate relevant data for prediction of future spread of quarantine pests

3• Development and establishment of suitable, widely accessible databases for the generated data

4• Models of climate change in different scenarios

5• Knowledge about the impact of different climate change scenarios

6• Development of risk management options for phytosanitary pests under changed climatic conditions

ANIHWA concerns animal health and welfare of farm animals, including fish and bees. The currently open call contains a topic on "improvement of preparedness for emerging and exotic diseases (including vector-borne diseases and zoonoses) by epidemiological approach to risk pathways identification" (also concerns CT2 marginally).

ERASYNBIO: Areas for potential synergy identified related to this core theme were:

Crop plants with novel properties regarding e.g. drought and other stress tolerance

ERA-CAPS is also related to this core theme (see above).

ERA-ARD2 is also marginally related to core theme 4.

Core theme 5: Greenhouse gas mitigation: N₂O and CH₄ mitigation in the agriculture and forestry sector, carbon sequestration, fossil fuel substitution and mitigating GHG emissions induced by indirect land use change.

ERASYNBIO: Areas for potential synergy identified related to this core theme were:

GHG as precursors for novel metabolic pathways; tailor-made production pathways for biofuels

ERA-CAPS, SUSFOOD and ERA-IB are marginally related to this core theme.

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